CITY OF COLUMBUS
OHIO

CONSTRUCTION AND MATERIAL SPECIFICATIONS

ONLINE VERSION April 1ST, 2021

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100 GENERAL PROVISIONS

ITEM 101 DEFINITIONS AND TERMS

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101.01 General. These Construction and Material Specifications are written to the Bidder before award of the Contract and to the Contractor after award of the Contract. The sentences that direct the Contractor to perform Work are written as commands. For example, a requirement to provide cold-weather protection would be expressed as, "Provide cold-weather protection for concrete," rather than "The Contractor shall provide cold-weather protection for concrete." In the imperative mood, the subject "the Bidder" or "the Contractor" is understood.

All requirements to be performed by others have been written in the active voice. Sentences written in the active voice identify the party responsible for performing the action. For example, "The Engineer will determine the density of the compacted material." Certain requirements of the Contractor may also be written in the active voice, rather than the active voice and imperative mood, if the sentence includes requirements for others in addition to the Contractor. For example, "If the Contractor, at any time, fails to comply with the provisions of 105.14, the Engineer will immediately notify the Contractor of such non-compliance."

Sentences that define terms, describe a product or desired result, or describe a condition that may exist are written in indicative mood. These types of sentences use verbs requiring no action. For example, "The characteristics of the soils actually encountered in the subgrade may affect the quality of the cement and depth of treatment necessary."

101.02 Abbreviations. The following abbreviations, when used in the Contract Documents, represent the full text shown below.

AAN	American Association of Nurserymen
AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
AIA	American Institute of Architects
AISC	American Institute of Steel Construction
AISI	American Iron and Steel Institute
ANSI	American National Standards Institute
AREA	American Railway Engineering Association
ASA	American Standards Association
ASCE	American Society of Civil Engineers
ASME	American Society of Mechanical Engineers
ASTM	American Society for Testing and Materials
AWG	American Wire Gage
AWPA	American Wood Preservers' Association
AWS	American Welding Society
AWWA	American Water Works Association
BMP	Best Management Practice (erosion)
BUSTR	Bureau of Underground Storage Tank Regulations (Division of Fire Marshal)
CCC	Columbus City Codes, 1959
CCRL	Cement and Concrete Reference Laboratory
CFR	Code of Federal Regulations
CMSC	Construction and Material Specifications - City of Columbus
CPESC	Certified Professional in Erosion and Sediment Control
CRSI	Concrete Reinforcing Steel Institute
EEI	Edison Electric Institute
EIA	Electronic Industries Alliance
EPA	Environmental Protection Agency
FEMA	Federal Emergency Management Agency
FHWA	Federal Highway Administration, Department of Transportation
FSS	Federal Specifications and Standards, General Services Administration
ICEA	Insulated Cable Engineers Association
GFRP	Glass-Fiber-Reinforced Polymer
IEEE	Institute of Electrical and Electronic Engineers
IES	Illuminating Engineering Society
IME	Institute of Makers of Explosives
IMSA	International Municipal Signal Association
IPCEA	Insulated Power Cable Engineering Association
IPS	International Pipe Standard

ISSA	International Slurry Seal Association
ITE	Institute of Transportation Engineers
JMF	Job Mix Formula
MSDS	Material Safety Data Sheets
NACE	National Association of Corrosion Engineers
NCHRP	National Cooperative Highway Research Program
NEMA	National Electrical Manufacturers Association
NHI	National Highway Institute
NIST	National Institute of Standards and Technology
NOI	Notice of Intent
NPDES	National Pollutant Discharge Elimination System
OAC	Ohio Administrative Code
ODNR	Department of Natural Resources
ODOT	Ohio Department of Transportation
ODOTCMS	Ohio Department of Transportation, Construction and Material Specifications
OEPA	Ohio Environmental Protection Agency
OMUTCD	Ohio Manual of Uniform Traffic Control Devices
ORC	Ohio Revised Code
ORDC	Ohio Rail Development Commission
OSHA	Occupation Safety & Health Act
OWPCA	Ohio Water Pollution Control Act
PCC	Portland Cement Concrete
PCI	Precast/Prestressed Concrete Institute
QA	Quality Assurance
QC	Quality Control
QPL	Qualified Products List or Approved Producers and Products List
RAP	Recycled Asphalt Pavement
RH	Relative Humidity
RPCC	Recycled Portland Cement Concrete
SAE	Society of Automotive Engineers
SSPC	Society for Protective Coatings
SWPPP	Storm Water Pollution Prevention Plan
UL	Underwriters' Laboratories, Inc.
USACE	United States Army Corps of Engineers

101.03 Definitions. The following terms or pronouns, when used in the Contract Documents, are defined as follows:

Addendum or Addenda. Written instructions issued by the City prior to Bid opening for the purpose of varying, modifying, rescinding or adding to portions of the Contract Documents104

Advertisement. The public announcement, as required by law, inviting Proposals for Work to be performed or materials and equipment to be furnished. Such Advertisement will indicate with reasonable accuracy the type, quantity and location of the Work to be done or the character and quality of the materials to be furnished and the time and place of the opening of Proposals.

Allowance. A non-biddable amount of money established by the City and included in the contract, which is set aside for a specific purpose, when the exact quantity of work for that specific purpose is not known at the time of bid.

Award. The written acceptance by the Director of a Proposal.

Bid. Same as Proposal**.**

Bid Documents. The Bid Documents include the Advertisement, Invitation for Bid, Instructions to Bidders, Addenda, Electronic Bidding Software file(s), Contract, Contract forms and required Guarantees, Specifications, Supplemental Specifications, Supplements, Special Provisions, Plans, Plan Notes, Standard Drawings, Technical Drawings, and any other document specifically designated by the Department as a Bid Document, all of which constitute one instrument. Any other documents provided with the bid are for informational purposes only and are not part of the Bid Documents. The City may request that the Bidder sign an acknowledgement that such informational documents are expressly excluded from the Contract.

Bidder. An individual, firm, partnership, or corporation submitting a Proposal for the advertised work, acting directly or through its duly authorized representative.

Borrow Area. The locations outside the right-of-way from which natural materials are removed for use in the Work.

Bridge. A structure, including supports, erected over a depression or an obstruction, such as water, highway, or railway, and having a track or passageway for carrying traffic or other moving loads and having a length measured along the center of roadway of more than 10 feet between the center line of bearing of abutments or extreme limits of openings for multiple boxes.

A. The length of a bridge structure is the over-all length measured between centerline of abutments.

B. The roadway width of a bridge structure is the clear width measured at right angles to the longitudinal centerline of the bridge between the bottom of curbs or guardrails or, in the case of multiple height of curbs, between the bottoms of the lower risers. For curb widths of one foot or less, the roadway width shall be measured between parapets or railings.

Business Day. Wherever indicated inside these specifications, business days are defined as: Monday, Tuesday, Wednesday, Thursday, and Friday, excluding National Holidays and, if applicable, the day that a National Holiday is observed.

Calendar Day or Day. Every day shown on the calendar.

Certified Test Data. A test report from a manufacturer's laboratory or independent laboratory listing actual test data for the specified City requirements for the samples tested and a statement by a person having legal authority to act for the supplier and/or manufacturer of the material that the test report furnished represents the material delivered to the City of Columbus project. The certification shall include the Laboratory Report No. and the name of the project to which the material is delivered. Laboratory reports signed by a Registered Professional Engineer and those signed by other personnel and notarized will be accepted for this purpose.

Change Order. A written order issued by the Engineer to the Contractor covering changes to the terms and conditions, plans and/or quantities, within or beyond the scope of the Contract and establishing the basis of payment from existing funding and any time adjustments for the Work affected by the changes.

City. The City of Columbus, acting through its Director or properly authorized agents thereof, such agents acting severally within the scope of the particular duties entrusted to them.

Claim(s). A request, by the Contractor, for adjustment in Contract Sum or Time, or both, when resolution is not reached using other provisions of the Contract.

Clean Hard Fill. Construction and demolition debris which consists only of reinforced or nonreinforced concrete, asphalt concrete, brick, block, tile, and/or stone which can be reutilized as construction material. Brick in clean hard fill includes, but is not limited, to refractory brick and mortar. Clean hard fill does not include materials contaminated with hazardous wastes, solid wastes, or infectious wastes. (OAC 3745-400-01(E))

Clean Soil. Clean soil consists of soil, rock, sand, and other unaltered nontoxic geological materials that are not contaminated with petroleum, PCB's, hazardous wastes (as defined in ORC 3734.01(J)), raw sewage, trash or other solid wastes (as defined in ORC 3734.01(E)), or mixed with vegetative debris, asphalt, concrete, scrap metal, bricks, pavement, or other man-made materials constituting construction and demolition debris.

Completion Date (Interim or Final). The date, as shown in the Contract Documents, by which the Work shall be completed (Final) or the date by which a portion of the Work defined by the Contract shall be completed (Interim).

Conduit. Any pipe or similar passageway for electricity, gas, water or other utility.

Construction Limits. These limits encompass all Work which includes removals, room for construction equipment to complete work, site access, etc.

Construction and Demolition Debris. Materials resulting from the alteration, construction, destruction, rehabilitation, or repair of any physical structure that is built by humans, including, without limitation, houses, buildings, industrial or commercial facilities, or roadways. Construction and Demolition Debris includes particles and dust created during demolition activities. "Materials resulting from the alteration, construction, destruction, rehabilitation, or repair of any man-made physical structure," are those structural and functional materials comprising the structure and surrounding site improvements, such as brick, concrete and other masonry materials, stone, glass, wall coverings, plaster, drywall, framing and finishing lumber, roofing materials, plumbing fixtures, heating equipment, electrical wiring and components containing no hazardous fluids or refrigerants, insulation, wall-to-wall carpeting, asphaltic substances, metals incidental to any of the above, and weathered railroad ties and utility poles. "Materials resulting from the alteration, construction, destruction, rehabilitation, or repair" do not include materials whose removal has been required prior to demolition, and materials which are otherwise contained within or exist outside the structure such as solid wastes, yard wastes, furniture, and appliances. Also excluded in all cases are liquids including containerized or bulk liquids, fuel tanks, drums and other closed or filled containers, tires, and batteries. (ORC 3714.01(C))

Contract Documents. The Contract Documents include the Advertisement, Invitation for Bids, Addenda, Proposal, Affidavits, Contract, Contract forms and required Guarantees, Specifications (CMSC), Supplemental Specifications, Supplements, Technical Specifications, Special Provisions, Plans, Plan Notes, Standard Drawings, "Accepted" and "Accepted as Noted" Working Drawings, Notice to Proceed, Notice of Commencement, and Auditor's Purchase Order as the same are published or may be published and amended by the City, Change Orders, Contract Modifications, and any other document included by reference by the City as a Contract Document, all of which constitute one instrument.

Contract Item (Pay Item). A specifically described unit of Work for which a price is provided in the Contract.

Contract Modification. A change to the terms and conditions of the executed Contract Documents beyond that approved by the City Council at the time of Contract award. A Contract Modification must be authorized by City Council.

Contract Performance and Payment Bond(s). The approved form of security, executed by the Contractor and its surety or sureties, guaranteeing complete execution of the Work as required by the Contract Documents and the payment of all legal debts pertaining to the construction of the Project.

Contract Price. The amount of compensation bid by the Contractor for a Contract Item in the Proposal or the amount of compensation established for a Contract Item added or modified pursuant to the Contract Documents.

Contract Sum. The Contract Sum is stated in the Contract and, including authorized adjustments thereto, is the maximum amount payable by the City to the Contractor for the performance of the Work under the Contract Documents. The Contract Sum may include a contingency amount; however, the contingency amount is not due to the Contractor unless approved by Change Order.

Contract Time. The number of workdays or calendar days, including authorized adjustments, allowed for completion of the Project. When a specified Completion Date is shown in the Contract Documents instead of the number of workdays or calendar days, completion of the Project shall occur on or before that date. Specified Completion Date and Calendar Day Contracts shall be completed on or before the day indicated even when that date is a Saturday, Sunday, or Holiday.

Contract. The written agreement between the City and the Contractor setting forth the obligations of the parties, including, but not limited to, legal terms and conditions, the performance of the Work, the furnishing of labor and materials, and the basis of payment.

Contractor. The individual, firm, partnership, or corporation contracting with the City for performance of prescribed Work, acting directly or through a duly authorized representative and qualified under the requirements of the Contract Documents.

Culvert. Any structure not classified as a Bridge that provides an opening under the roadway.

Department. The department of the City of Columbus under which the Project is being performed.

Director. The Director of the City department under which the Project is being funded or the department that is holding the Contract.

Engineer. The Engineer, Architect, Planner, or other authorized representative of the City of Columbus working under the supervision of the Administrator of the Division under which the project is being performed. The Engineer, or the Engineer's authorized representative, is the duly authorized agent of the City acting within the scope of its authority for purposes of engineering and administration of the Contract.

Engineered Drawings. A type of Working Drawing that requires the practice of engineering as defined in ORC 4733.01(E). Examples of Engineered Drawings include: Excavation Bracing Plans, Demolition Plans, Erection Plans, Falsework Plans, Cofferdam Plans, Causeway Plans, Jacking and Temporary Support Plans, Plans for Heavy Equipment on Structures, Plans for structures for Maintaining Traffic, and Corrective Work Plans.

Equipment. All machinery and equipment, together with the necessary supplies for upkeep and maintenance, and also tools and apparatus necessary for the proper construction and acceptable completion of the Work.

Extra Work. An item of Work not provided for in the Contract as awarded but found necessary to the satisfactory completion of the Contract within its intended scope.

Fabricator. The individual, firm, or corporation that fabricates structural metals or prestressed concrete members as an agent of the Contractor.

Field Order. A written order to the Contractor directing a minor change in the Work but that does not involve an adjustment in the Contract Sum or an extension of the Contract Time and is not inconsistent with the intent of the Contract Documents.

Inspector. The Engineer's authorized representative assigned to make detailed inspections of Contract performance.

Laboratory. The testing laboratories of the City.

Invitation for Bid. A written invitation to contractors or equipment suppliers to submit a Proposal on a specific project to be realized or a product or service to be furnished.

Materials. Any materials or products specified for use in the construction of the Project and its appurtenances.

National Holidays. New Year's Day, January 1; Martin Luther King's Birthday - the Third Monday in January; Presidents' Day, the Third Monday in February; Memorial Day, the last Monday in May; Independence Day, July 4; Labor Day, the First Monday in September; Veterans Day, November 11; Thanksgiving Day, the fourth Thursday in November; Christmas Day, December 25.

Notice of Intent to Award. Written notice by the City to the apparent successful bidder stating that upon compliance with the conditions enumerated therein, the City intends to enter into a Contract.

Notice of Commencement. Legal notice by the City indicating the beginning of construction on a public improvement.

Notice to Proceed. Written notice to the Contractor, by the Director or the Director's authorized representative, authorizing the beginning of Work and setting forth the Completion Date.

Owner. The Department or Division of the City of Columbus that invited Bids and is financially responsible for the Project.

Plans. The drawings, standard drawings, and supplemental drawings, provided by the City, that show the location, character, dimensions and details of the Work. Plans do not include any electronic data provided as information to the Bidder and expressly identified as "for informational purposes only".

Prebid Question. A written inquiry submitted by a prospective Bidder.

Profile Grade. The trace of a vertical plane intersecting the top surface of the proposed wearing surface, usually along the longitudinal centerline of the roadway, or as indicated on the plans. Profile grade means either elevation or gradient of such trace according to the context.

Project. The Work together with all appurtenances and construction to be performed under the Contract.

Project Limits. Project limits are points on the mainline centerline of construction where the proposed improvement, as described in the project description on the Title Sheet (excluding incidental construction), begins and ends.

Proposal (or Bid). The offer of a Bidder, on the prescribed forms properly signed and guaranteed, to perform the Work and to furnish the labor and materials at the prices quoted. Throughout the Contract, the terms Proposal and Bid are used interchangeably.

Proposal Form. The approved form on which the City requires Proposals to be prepared and submitted for the Work.

Proposal Guaranty. The approved form of security furnished with a Proposal to guarantee that the Bidder will enter into the Contract if its Proposal is accepted.

Reasonably Close Conformity. Compliance with reasonable and customary manufacturing and construction tolerances where working tolerances are not specified. Where working tolerances are specified, reasonably close conformity means compliance with such working tolerances and the completed Work or portion of Work functions or performs as intended. Without detracting from the complete and absolute discretion of the Engineer to insist upon such tolerances as establishing reasonably close conformity, the Engineer may accept variations beyond such tolerances as reasonably close conformity where they will not materially affect the value or utility of the Work and the interests of the City.

Registered Architect. An Architect registered with the Ohio Architects Board to practice architecture in the State of Ohio.

Registered Professional Engineer. An engineer registered with the Ohio State Board of Registration for Professional Engineers and Surveyors to practice professional engineering in the State of Ohio.

Registered Surveyor. A surveyor registered with the Ohio State Board of Registration for Professional Engineers and Surveyors to practice professional surveying in the State of Ohio.

Request for Information (RFI). Request from Contractor seeking interpretation or clarification of the Contract Documents.

Right-of-Way. A general term denoting land, property, or interest therein, acquired for or devoted to Project purposes and extending to the limits under the control of the state or local authority.

Road. A general term denoting a public way for purposes of vehicular travel, including the entire area within the Right-of-Way.

Roadbed. The graded portion of a highway within top and side slopes, prepared as a foundation for the pavement structure and shoulder.

Roadside. The areas between the outside edges of the shoulders and the Right-of-Way boundaries. Unpaved median areas between inside shoulders of divided highways and infield areas of interchanges are included.

Roadway. The portion of a highway or street within limits of construction.

Sewer. Pipe or conduit intended for carrying storm or sanitary flow.

Shoulder. The portion of the roadway contiguous to the traveled way for accommodation of stopped vehicles, for emergency use, and for lateral support of base and surface courses.

Shop Drawings. The drawings provided by the Contractor or Supplier that describe any portion of the Work that will remain in place permanently.

Sidewalk. The facility within the public Right-of-Way primarily constructed for the use of pedestrians.

Special Provisions. Additions and revisions to the standard and Supplemental Specifications covering conditions applicable to an individual Project.

Specialty Items. Work specified by the Contract Documents that requires specialized knowledge and/or equipment and materials to perform.

Specifications (CMSC). The directions, provisions, and requirements contained herein as supplemented by the Supplemental Specifications and Special Provisions.

State. The State of Ohio acting through its authorized representative.

Street. A general term denoting a public way for purpose of vehicular travel, including the entire area within the Right-of-Way.

Structures. Bridges, culverts, catch basins, curb inlets, drop inlets, retaining walls, cribbing, manholes, endwalls, buildings, curbs, pavements, sewers, water mains, service pipes, underdrains, foundation drains, and other features that may be encountered in the Work and not otherwise classified herein.

Subcontractor. An individual, firm, partnership or corporation to whom the Contractor sublets part of the Contract to be performed on the job site.

Subgrade. The surface upon which a structure or work and appurtenances are to be constructed.

Substantial Completion. The date at which the Project is complete and ready for beneficial use, as determined by the Engineer, such that it can be safely and effectively used by the public without further delays, disruption, or impediments.

Substructure. All of that part of the structure below the bearings of simple and continuous spans, skewbacks of arches, and tops of footings of rigid frames, together with backwalls and wings.

Superintendent. The Contractor's authorized representative in responsible charge of the Work.

Superstructure. The entire structure except the Substructure.

Supplement. A list of requirements for fabrication plants, methods of test, or other miscellaneous requirements that are maintained on file with either the City of Columbus (CS) or the Ohio Department of Transportation (OS).

Supplemental Specifications. Detailed specifications supplemental to or superseding these Specifications.

Surety. The corporation, partnership, or individual, other than the Contractor, executing a bond (or bonds) furnished by the Contractor.

Technical Specification. Written depiction of design drawings and a detailed and exact statement of particulars, especially a statement prescribing materials, dimensions, and workmanship for something to be built or installed.

Titles (or Headings). The titles or headings of the sections and subsections herein are intended for convenience of reference and shall not be considered as having any bearing on their interpretation.

Waste Area. Locations outside the right-of-way upon which materials from the Work are to be deposited as waste.

Water Main. Conduit for carrying public water supply.

Work. The furnishing of all labor, services, materials, equipment, and other incidentals necessary or convenient to the successful completion of the Project and the carrying out of all duties and obligations imposed by the Contract Documents.

Work Days. Wherever indicated inside these specifications, workdays are defined as: Monday, Tuesday, Wednesday, Thursday, Friday, and Saturday, excluding National Holidays and, if applicable, the day that a National Holiday is observed.

Work Limits. The farthest limits of the Contractor's responsibility on a project, including all temporary and incidental construction, with the exception of work zone traffic control devices required for maintenance of traffic. The Contractor is restricted from working beyond the limits shown in the Contract Documents without approval by the City.

Working Drawings. Stress sheets, shop drawings, submittals, Engineered Drawings, erection plans, falsework plans, installation plans, certified drawings, frame work plans, cofferdam plans, bending diagrams for reinforcing steel, or any other supplementary plans or similar data that the Contractor is required to submit in order to describe any portion of the Work.

101.04 Interpretations. In order to avoid cumbersome and confusing repetition of expressions in these Specifications, it is provided that whenever anything is, or is to be, done, if, as, or, when, or where "contemplated, required, determined, directed, specified, authorized, ordered, given, designated, indicated, considered necessary, deemed necessary, permitted, reserved, suspended, established, approval, approved, disapproved, acceptable, unacceptable, suitable, accepted, satisfactory, unsatisfactory, sufficient, insufficient, rejected, or condemned," unless expressly otherwise provided, it shall be understood as if the expression were followed by the words "by the Engineer" or "to the Engineer".

ITEM 102 BIDDING REQUIREMENTS AND CONDITIONS

102.01 Pre-qualification of Bidders
102.02 Availability and Contents of Bid Documents
102.03 Preparation of Proposals
102.04 Interpretation of Quantities in Proposal
102.05 Examination of Contract Documents and Work Site
102.06 Duty to Notify of Errors in Bid Documents
102.07 Bid Award Determination
102.08 Non-Responsive Proposals
102.09 Rejection of Unbalanced Bid
102.10 Proposal Guaranty
102.11 Delivery of Proposal
102.12 Withdrawal of Proposals Prior to Bid Opening
102.13 Withdrawal of Proposals after Bid Opening (Mistake in Bid)
102.14 Public Opening of Proposals
102.15 Material Standards

102.01 Pre-qualification of Bidders. Pursuant to Chapter 329 of the Columbus City Code, Bidders shall be prequalified.

102.02 Availability and Contents of Bid Documents. Bid Documents are available to prospective bidders at the location stated in the Advertisement. The Bid Documents will state the location and description of the contemplated Work and will show the approximate estimate of the various quantities and kinds of work to be performed or materials to be furnished, and will have a schedule of items for which unit bid or lump sum prices are invited. The Bid Documents will state the Contract Time, the amount and type of the Proposal Guaranty, and the date, time and place of the opening of Proposals. The Plans, Specifications, Supplemental Specifications, Special Provisions, standard drawings or other documents designated in the Bid Documents, will be considered a part of the Proposal whether attached or not.

102.03 Preparation of Proposals. Prepare a Proposal according to this subsection and the requirements found in the Bid Documents.

A. General. Provide prices for each item listed in the Proposal.

When an item in the Proposal contains a choice to be designated by the Bidder, the Bidder shall indicate that choice in accordance with the Specifications for that particular item, and thereafter no further choice will be permitted.

The Proposal shall include all documents, duly executed as applicable, that are required to be submitted as directed in the Advertisement and as described in Item 102.02.

ENTITY SUBMITTING PROPOSAL
REQUIRED SIGNATURE

Individual	The individual or a duly authorized agent.
Partnership	A partner or a duly authorized agent.
Joint Venture	A member or a duly authorized agent of at least one of the joint venture firms.
Corporation	An authorized officer or duly authorized agent of the corporation. Also, for paper bids, show the name of the state chartering the corporation and affix the corporate seal.
Limited Liability Company	A manager, a member, or a duly authorized agent.

Anyone signing a Proposal in a representative capacity must provide evidence of his or her authority to bind the bidder by Affidavit.

Before a contract will be awarded to a foreign corporation or an individual or partnership non-resident of the State of Ohio, such foreign corporation, individual, or partnership non-resident shall register with the Secretary of State's office for the purpose of accepting service of summons, in any action in law or equity, or both, brought in the State of Ohio.

B. Submitting Bids Electronically. When submitting a Bid electronically, properly complete the electronic file and submit it using the software specified in the Bid Documents rather than completing it by handwriting, typing, or using unauthorized computer-generated forms. Properly execute the Proposal by completing all of the required fields and attaching the required signatures in the spaces provided in the electronic file.

C. Submitting Paper Bids. When submitting a paper Bid, submit the Proposal upon the forms furnished by the City.

Specify a unit price in figures for each proposal item for which a quantity is given in the "Unit Price" column. Calculate and place the products for the respective unit prices and quantities in the "Bid Amount" column. For a lump sum item, place the same price in the "Unit Price" column and in the "Bid Amount" column pertaining to that item. Indicate the total Proposal amount by adding the values entered in the "Bid Amount" column for the listed items. All the words shall be in ink or typed.

Computer Generated Bid Sheet: If permitted in the Bid Documents, the Bidder may submit an 8 1/2 x 11 inches computerized bid sheet or sheets attached to the Proposal. The computerized bid sheet or sheets must meet the following requirements:

1. reference numbers, description, units and quantities included,
2. a unit price per/item,
3. an extension price per/item,
4. project name, number, and date on each sheet,
5. subtotals and totals clearly identified,
6. blanks where appropriate,
7. in the event of a deleted item - the word deleted inserted,
8. lines between columns and items,
9. each page numbered,
10. a general summary of subtotals must be shown on the last sheet,
11. the Contractor's contract compliance number must appear on each computerized sheet,
12. the following statement must appear on the last sheet of the computerized bid:

"The Bidder's TOTAL is only for reference at the bid opening. The City will verify that the TOTAL price and the individual unit and/or lump sum prices correspond. If there is a discrepancy, the unit and/or lump sum prices shall govern."

Be advised further that the Bidder is solely responsible to prepare its computerized bid sheets in accordance with the above requirements and the remaining requirements of this Section. Failure to fully comply with the designated format may result in the rejection of the Bidder's bid.

102.04 Interpretation of Quantities in Proposal. The quantities appearing in the Proposal are approximate only and are prepared for the comparison of Bids. Payment to the Contractor will be made only for the actual quantities of Work performed and accepted or materials furnished and accepted in accordance with the Contract Documents. The scheduled quantities of Work to be done and materials to be furnished may each be increased, decreased, or omitted as hereinafter provided.

The description of unit price items in the Proposal that are identified as "increase or decrease" items are identified for the purpose of establishing a unit price for payment for increases or decreases in the particular item during performance of the Work. For the purpose of Proposal preparation and evaluation, all such "increase or decrease items" shall be computed as increases. Any amount noted as "increase or decrease" will not be used to determine the percentage of work provided by the Contractor and its subcontractors.

102.05 Examination of Contract Documents and Work Site. The Bidder is expected to conduct a reasonable Project site investigation of the proposed Work and examine carefully the Bid Documents, and all other documents furnished or referenced by the City in the Bid Documents,

before submitting a Proposal. When available, the City may include in the Bid Documents or make available to Bidders for review at the designated City location additional documents, such as: as-built drawings, subsurface investigations, borings, soundings, water levels, elevations or profiles and results of preliminary investigations. The Contractor's reasonable site investigation shall also include (1) review of these documents (but this is not substitute for Bidder's own investigation, interpretation, or judgment), and (2) investigation of the Project site, borrow sites, site access, hauling routes and all other locations related to the performance of the Work. The City reserves the right to direct that the Contractor perform a mandatory site inspection.

The Bidder shall, as and to the extent necessary, also make additional investigations of the Project site and existing and subsurface conditions as it deems necessary prior to submitting the Proposal. The Bidder must obtain approval of the City prior to conducting any boring or subsurface exploration testing that may disturb existing field conditions.

Submitting the Proposal is an affirmative statement that the Bidder has made a reasonable investigation of the proposed Work, the Project site, and the Contract Documents and is satisfied as to the character, quality, quantities and conditions to be encountered in performing all Work and as to the requirements of the Contract Documents.

The Bidder's investigation and examination shall be at the Bidder's expense and at no cost to the City. Any physical variance at the Project site from that indicated by the Contract Documents, discovered by the Bidder during any investigation or examination conducted by the Bidder shall be called to the attention of the City in writing prior to submitting a Proposal as provided in 102.06.

No claims of ignorance of any requirements of the Contract Documents or of any available data shall be accepted as a basis for any Claim for any extra compensation, extra work, or extension of time.

102.06 Duty to Notify of Errors in Bid Documents. The Bidder shall promptly notify the City of errors and/or omissions in the Bid Documents which the Bidder discovers in the exercise of ordinary and reasonable care. The Bidder's notification shall be made by submitting a question in writing and in accordance with the Bid Documents prior to submitting a Proposal. The Bidder's duty to disclose errors and omissions is not only a bidding requirement but is also a legal requirement that cannot be ignored.

Failure to provide the required notification prior to the opening of Proposals shall constitute a waiver by the Contractor and shall not obligate the City for any costs based upon any apparent or patent ambiguity arising from insufficient data or obvious errors in the Bid Documents. Knowingly withholding information regarding an error or omission in the Bid Documents, or intentionally misrepresenting an item of Work for financial or competitive gain, may result in civil or criminal penalties.

102.07 Bid Award Determination. Pursuant to Chapter 329 of the Columbus City Code, the City shall determine which Bidder to award the Contract.

102.08 Non-Responsive Proposals. The City reserves the right to disqualify or refuse to consider a Proposal for any of the following reasons:

1. Whether bidder has submitted more than one bid for the same work from an individual or entity under the same or different name, or corporation under the same name, or corporations with one or more of the same persons as officers or directors of such corporations, or corporations which are holding companies, parent companies or holding companies that are subsidiaries of such corporations.
2. Whether bid prices are materially unbalanced as defined by 102.09.
3. Whether bidder has failed to comply with pre-qualification requirements of 102.01.
4. Whether the bidder failed to comply with the licensed water contractor and licensed sewer tapper requirements of 107.02.
5. Whether the bid contains conditions or qualifications not provided in the Bid Documents.
6. Whether the bidder failed to acknowledge addenda or the bid does not contain complete forms required to be included in the bid and the city determines that the bidder's bid does not respond to the Bid Documents in all material respects or contains irregularities or deviations which affects the amount of the bid or otherwise gives the bidder a competitive advantage.
7. Whether bidder adds a provision reserving the right to accept or reject an award.
8. Whether bidder fails to submit a unit price for each contract item listed, when required by the invitation for bid.
9. Whether bidder fails to submit a lump sum price where required.
10. Whether the bidder fails to submit the required bid guarantee or submits an irregular bid guarantee for the amount required.
11. Whether the bid contains other alterations, omissions, or errors such that, in the judgment of the City, the bid does not respond to the Bid Documents in all material respects, or contains irregularities or deviations from the Bid Documents that affect the amount of the bid or otherwise gives the bidder a competitive advantage.
12. Whether the bidder has complied with the requirements of Chapter 329 of the Columbus City Code regarding subcontractors.
13. Whether the bidder has complied with the requirements of Chapter 3906 of the Columbus City Code regarding its valid contract compliance certification number.

However, should the City accept a non-responsive Proposal, the Bidder must meet all remaining requirements set forth in the Bid Documents.

102.09 Rejection of Unbalanced Bid. The Bidder is required to bid each item as indicated in the Bid Documents. The City reserves the right to reject any materially unbalanced bid. A "materially unbalanced bid" is a Bid that contains lump sum or unit prices that do not reflect reasonable labor, equipment, and material costs plus a reasonable proportionate share of overhead and other indirect costs and anticipated profit, and the City determines that the Bid may not result in the lowest ultimate cost to the City.

102.10 Proposal Guaranty. The required type of bid guarantee shall be identified in the invitation for bid and may take the form of a bid or proposal bond, a certified or cashier's check drawn on a solvent bank, or a letter of credit pursuant to Chapter 1305 of the Ohio Revised Code. If a bid or performance and payment bond is required, the bid or performance and payment bond shall be issued by a guaranty company authorized to do so under the Ohio Revised Code or by a surety who is: (1) a resident of this state; (2) worth, in the aggregate, double the sum to be secured, beyond the amount of their debts; and (3) have property liable to execution in the state equal to the sum to be secured. The bid guarantee shall be for a minimum of ten (10) percent of the bid amount.

102.11 Delivery of Proposal. Unless otherwise indicated in the Bid Documents, all Proposals must be submitted using the electronic Bid submission software specified in the Proposal. The City will accept Proposals until the time and date designated in the Advertisement and the Invitation for Bid. If a paper bid is provided, the City will return Proposals received after the designated time to the Bidders unopened, at the Bidder's expense.

102.12 Withdrawal of Proposals Prior to Bid Opening. Prior to the opening of Proposals, a Bidder may withdraw its Proposal. If a paper bid has been submitted, the Bidder must make a written request that is received by the Director prior to the time of Proposal opening. The Proposal will be returned to the Bidder unopened.

102.13 Withdrawal of Proposal after Bid Opening (Mistake in Bid). The Director may permit a Bidder to withdraw the Bid from consideration without forfeiture of the Proposal Guaranty provided that the Bidder identifies the mistake and provides a written request to the Director within two business days after the Bid opening. The written request must also include a sworn notarized statement specifying the grounds for withdrawal together with the original bid work sheets which document the mistake.

The following conditions must be met for Bid withdrawal after Bid opening:

1. The Bid was substantially lower than the other Bids;
2. The Bid was made in good faith;
3. The mistake was a non-judgmental, clerical or mathematical error or an unintentional omission of a substantial quantity of work, labor or material; and
4. The amount of the error must have a significant monetary effect on contract performance.

The City may require a meeting with the Bidder before a determination is reached. The City will notify the Bidder in writing of its determination.

If the Director determines that the conditions for withdrawal have not been met, the Director may award the Contract to such Bidder. If such Bidder does not enter into the Contract and/or furnish the required performance and payment bond, the Director may, as applicable, declare the Proposal Guaranty forfeit and proceed with recovering the Proposal Guaranty. In addition, the Director may award the Contract to the next lowest responsive and responsible Bidder or reject the remaining Bids and re-advertise the Project.

If the Bidder is permitted to withdraw its Bid, it will not be permitted to participate in the Project for which the Bid is withdrawn.

102.14 Public Opening of Proposals. Proposals will be opened and read in accordance with Chapter 329 of the Columbus City Code at the time and place designated in the Bid Documents. Bidders, their authorized agents, and other interested parties are invited to be present.

102.15 Material Standards. The equipment, items, devices, materials, forms of construction, fixtures, etc., named specifically in the Contract Documents, including any approved materials lists provided by an individual Department or Division, have been selected by the City to establish a standard for the type and equality of article to be furnished. The Bid evaluation shall be based upon the Contractor furnishing these specified standards.

Before any Contract is awarded, the City may require the Bidder to furnish a complete statement of the origin, composition, and manufacture of any or all materials to be used in the construction of the Work. The City may test the samples as specified in these Specifications to determine their quality and fitness for the Work.

When a standard is specified accompanied by the words "or equal," the product of any source may be submitted for review and consideration during the course of construction provided that the product furnished is equal in all respects to the specified standard and the Contractor certifies that the item is equal in quality and all aspects of performance and appearance to that specified. The Engineer may request additional information and documents as deemed necessary to make the determination that the item is "equal".

The Engineer shall be the sole judge of the fitness of all items submitted for approval as "or equals". The Engineer alone shall determine the extent of any special features or modifications required to render an "or equal" item acceptable in all respects to be considered "an equal" to a specified standard, the "or equal" item must not detract from the quality of performance which would have been provided by the use of the specified standard. Determination of equality will consider materials of construction, design features, construction features, compatibility with adjacent items of work, performance parameters, maintainability, durability, operability, finish and workmanship, quality of service representation, maintenance and operation documentation, financial ability of the manufacturers, locations of successful installations, compliance with the Contract Documents and other qualities that may affect the determination.

Should special features or modifications be required upon the substitution or modifications to the adjacent features of the Work are required to accommodate the product, such features or modifications shall be made at no additional cost to the City. If the Engineer is not satisfied that the "or equal" item is an acceptable replacement to the specified standard, the specified standard shall be furnished by the Contractor at no additional cost to the City.

ITEM 103 AWARD AND EXECUTION OF CONTRACT

103.01 Consideration of Proposals
103.02 Award of Contract
103.03 Cancellation of Award
103.04 Return of Proposal Guaranty
103.05 Contract Performance and Payment Bond
103.06 Execution of Contract
103.07 Failure to Execute Contract and Furnish Performance and Payment Bond(s)
103.08 Responsibility to General Public
103.09 Contractor's Insurance

103.01 Consideration of Proposals. After the Proposals are opened and read, as required by the Columbus City Code, the City will compare the Bidders' proposed prices. The proposed price is the summation of the products of the estimated quantities shown in the Proposal and the unit prices and, if applicable, lump sum bid prices. In the event of a discrepancy between unit bid prices and extensions, the unit price shall govern.

The City reserves the right, without any liability, to reject any or all Proposals, to waive minor technicalities, or to advertise for new Proposals.

103.02 Award of Contract. The City will award the Contract to the Bidder as determined by Chapter 329 of the Columbus City Code.

Prior to the City awarding a Contract, the Bidder must have an active contract compliance number under provisions of City Code, Title 39.

103.03 Cancellation of Award. The City reserves the right to rescind the award of any Contract at any time before the final execution of the Contract by the City without any liability.

103.04 Return of Proposal Guaranty. If the bid is submitted on paper, the City shall, within 10 business days after issuance of the Notice of Intent to Award, return all proposal guarantees, except those of the three lowest bidders. The City shall return the retained proposal guarantees within 10 business days after the City has entered into contact for the project. If a bid is deemed non-responsive, the City shall return the proposal guarantee within 10 business days of the bid opening. If the City receives an electronic bid, the Proposal Guaranty shall not be returned.

103.05 Contract Performance and Payment Bond. The successful Bidder must, before execution of the Contract by the City, furnish a Contract performance and payment bond(s) in the full amount of the Proposal. Said bond(s) shall cover the entire Contract Sum, including the guarantee period required under 109.13. The successful Bidder's failure to return the signed Contract and the Contract performance and payment bond(s) shall be deemed a failure by the Contractor to enter into the Contract and shall release the City from all obligations to the Bidder.

103.06 Execution of Contract. The successful Bidder shall sign and return the Contract, together with the contract performance and payment bond(s) and other required Contract Documents, within ten business days after receiving the Notice of Intent to Award and the Contract Documents for signature. No Proposal shall be considered binding upon the City until the Director receives approval from Columbus City Council to enter into said Contract, the Contract is executed and a purchase order is approved by all applicable City Agencies. If the Contract is not executed by the City within thirty days following the effective date of the authorizing legislation approved by City Council, the successful Bidder will have the right to withdraw its Bid without prejudice.

The Contractor must keep one copy of the Specifications (CMSC), and one set of the Contract Documents at the Project site at all times. The Contractor shall supply the owner with five sets of Plans. A digital copy of the conformed set will be provided to the Contractor at the pre-construction meeting. One full-size set and four half size (11"x17") sets, unless directed otherwise by the City, shall be delivered to the City prior to the start of any work on the project. For projects including waterline work necessitating waterline as-builts, one additional and separate full-size set of the waterline section sheets and plan title sheet with signatures shall be provided.

103.07 Failure to Execute Contract and Furnish Performance and Payment Bond(s). If Bidder does not enter into the Contract and/or furnish the required performance and payment bond within ten business days after receiving the Contract Documents for signature, the Director may, as applicable, declare the Proposal Guaranty forfeited. Award may then be made to the next lowest, responsive, responsible, and best Bidder, the Project may be re-advertised, or any other action may be taken as the Director may decide.

103.08 Responsibility to General Public. The Contractor shall defend, indemnify and hold harmless the City of Columbus and any of its agents or representatives, employees, assigns and successors in interest, from and against any lawsuits and causes of action, claims, losses, demands and expenses, including but not limited to reasonable attorney fees and the cost of litigation, damages or liability of any nature whatsoever, for death or injury to any person, including employees or agents of the Contractor, or for damage to or destruction of property of either party hereto or any third party, which arise in any manner from the negligent acts, errors, omissions or willful misconduct of the Contractor and any of its agents, employees or representatives, including any of its subcontractors, in the performance of the Contract for the City of Columbus.

The Contractor shall procure and maintain during the term of the Contract and any applicable warranty period insurance for the liability of damages, which are imposed by law or assumed under Contract with the City of Columbus, in the kind and minimum amounts as specified hereinafter, from insurance companies which are authorized to transact business under the laws of the State of Ohio. The insurance shall protect the Contractor and any Subcontractor performing work under the Contract with the City of Columbus from claims for damages which may arise from operations under the Contract, whether such operation is performed by the Contractor or by any Subcontractor or by anyone directly or indirectly employed by either of them. The cost of such insurance shall be incidental to all contract items. The City of Columbus shall be listed as an 'Additional Insured' on the Commercial General Liability and Comprehensive Automobile liability insurance policies.

Prior to the execution of the Contract, the Contractor shall provide the City of Columbus with a 'Certificate of Insurance', in a satisfactory form, which demonstrates compliance with the requirements of this subsection. The 'Certificate of Insurance' will also reference the Contract and Project Number for which the work is being performed. The Contractor shall also be responsible for providing a 'Certificate of Insurance' within ten

business days after the insurance is renewed. If the insurance is subject to cancellation, then the insurance company shall immediately notify the City of Columbus of such cancellation in accordance with the policy terms for affording such notice. Also, if the insurance is cancelled, then the Contractor will immediately cease all operations until the required kind and limits of insurance have been restored. Upon request, the Contractor shall furnish the City of Columbus with a certified complete copy of each policy of insurance. The Contractor shall not commence work under the Contract until the Contractor has obtained all insurance required by 103.09 and such insurance has been approved by the City.

103.09 Contractor's Insurance. For purposes of complying with 103.08, the Contractor shall furnish evidence of procuring the following types of insurance prior to the execution of the Contract:

A. Commercial General Liability Insurance. This policy shall provide coverage for bodily injury or property damage which may arise from the operations of the Contractor and any of its subcontractors. The policy shall include coverage for premises and operations; independent contractors; products and completed operations; broad form property damage; hazards of explosion, collapse, and underground damage; and contractual liability as applicable to any indemnification hold harmless agreements in the Contract. The minimum limits of liability shall be $1,000,000 for each occurrence subject to an aggregate liability for products and completed operations of $2,000,000 and a general aggregate liability of $2,000,000.

B. Comprehensive Automobile Liability Insurance. This policy shall provide coverage for owned, non-owned, and hired automobiles for all damages arising from bodily injury and property damage with limits of liability of not less than $1,000,000 per accident with respect to bodily injury, property damage, or death.

C. Workers' Compensation Insurance. The Contractor shall comply with all provisions set forth by the Ohio Bureau of Workers' Compensation during the term of the Contract for the benefit of all employees employed at the project site. If the Contractor shall engage the services of Subcontractors, then it shall require all such Subcontractors to also provide Workers' Compensation Insurance for its employees who are employed at the project site. In order to comply with this requirement, the Contractor shall provide the City of Columbus with a copy of the Workers' Compensation Certificate as evidence that its insurance premium and that of any Subcontractor has been paid. In the event any class of employees engaged in hazardous work under the Contract at the site of the project is not protected under the Workers' Compensation statute, the Contractor shall provide and cause each Subcontractor to provide suitable insurance for the protection of their employees not otherwise protected.

D. Employers Liability Insurance. This policy shall provide coverage for accident or disease which is incurred by an employee of the Contractor in an amount of not less than $100,000 for bodily injury by Accident for each accident, $100,000 for bodily injury by Disease for each employee, and a policy limit of $500,000 for bodily injury by disease.

E. Builders Risk Insurance. When required, the Contractor shall procure and maintain during the term of the Contract Builders Risk insurance to protect the work being performed under the Contract from loss as a result of fire, hail, lightning, theft, wind storm, and vandalism in the full amount of the Contract. The cost for this insurance shall be included in the unit price for 'Item Special – Builders Risk Insurance'. If the project is bid as a lump sum, Builders Risk Insurance shall be included in the lump sum price the same as other overhead costs.

F. Railroad Protective Liability Insurance. When required, the Contractor shall procure and maintain during the term of the Contract a Railroad Protective Liability insurance policy, for the benefit of the named railroad with respect to the operations of the Contractor and its Subcontractors, with limits of liability as specified by the railroad, for damages arising from bodily injury, death, or property damages combined in any one occurrence. The cost for this insurance shall be included in the unit price for 'Item Special – Railroad Protective Insurance'. If the project is bid as a lump sum, Railroad Protective Liability Insurance shall be included in the lump sum price the same as other overhead costs.

G. Professional Liability Insurance. When required, the Contractor shall furnish evidence that it or any of its Sub-consultants maintain Professional Liability insurance, for liability which may arise from the negligent acts, errors, or omissions of operations performed under the Contract, in an amount not less than $1,000,000 for each claim. If such policy is written on a 'claims-made' form, then it shall have a retroactive date of no later than the effective date of the Contract, and such policy shall be maintained for a period of not less than two years after the project has been accepted by the City of Columbus. If the project is bid as a lump sum, Professional Liability Insurance shall be included in the lump sum price the same as other overhead costs.

An excess liability insurance policy may be utilized to satisfy the requirements of insurance for Commercial General Liability and Comprehensive Automobile Liability insurance. If such a policy is utilized, then the City of Columbus shall be listed as an 'Additional Insured'. If the insurance required of this Section is not renewed or if the available insurance is less than the required minimum amounts specified herein as a result of a change or modification in coverage or if the limits of liability are impaired by claims so as to reduce the amount of available insurance, then the Contractor shall notify the City of Columbus in which case the City of Columbus may at its sole discretion consider the Contractor in default of its Contract, refuse to make any further payment to the Contractor until such time the deficiency in insurance is satisfactorily resolved, or use any retained funds which are due the Contractor in order to remedy the deficiency. If any part of the Contract is let to a Subcontractor, then the Contractor is responsible for the part subcontracted work being adequately covered by insurance herein-above described.

ITEM 104 SCOPE OF WORK/CHANGES

104.01 Intent of the Contract
104.02 Modifications of the Contract Documents
104.03 Contractor Notification, Continuation of Work, and Claims
104.04 Maintenance of Traffic and Accessibility to Utilities
104.05 Rights In and Use of Materials Found on the Work Site
104.06 Right of Property in Materials
104.07 Final Cleaning Up

104.08 Recordkeeping/Audit

104.01 Intent of the Contract. The intent of the Contract is to provide for the construction, execution and completion of every detail and element of the Work in accordance with the Contract Documents. The Contractor shall perform all items of work covered and stipulated in the Proposal, perform altered and extra work, and furnish all labor, materials, equipment, tools, transportation and supplies required to complete the Work in accordance with the Contract Documents. Should any dispute or misunderstanding arise as to the intent or meaning of any of the Contract Documents, or any discrepancy therein, the decision of the Engineer shall be final and conclusive as to the requirements for performance of the Work; provided, however, if the Contractor disagrees with such decision, it may dispute the decision in accordance with 104.03.

The price for items of work or materials shown or provided for in the Contract Documents for which no separate line item unit price is given shall be distributed among the various Bid items. Submission of a Proposal shall be considered evidence and acknowledgement that the Bidder is satisfied with the Contract Documents and the conditions as shown therein. No additional compensation shall be paid or time given to the Contractor for compliance with the Contract Documents, except as and to the extent expressly provided in the Contract Documents.

104.02 Modifications of the Contract Documents.

A. General. The City may at any time, without invalidating the Contract and without notice to or release of the sureties, by written Change Order or Contract Modification, as applicable, make any change or modification in the Work or add to the Work within the general scope of the Contract, including, but not limited to, changes in the Contract Documents; in the sequence of the Work; or in the City-furnished facilities, equipment, materials, services, or site. The Contractor shall ensure that the amount of the surety bonds is modified as necessary from time to time to be consistent with any changed Contract scope, Sum or Time in accordance with any Change Order(s) or Contract Modification(s).

The Contractor shall have no right to compensation above the Contract Sum until the extra work is included in a written Contract Modification approved by the City Council.

B. Differing Site Conditions. If subsurface or latent physical conditions are encountered at the Project site that (i) differ materially from those indicated in the Contract Documents or (ii) if unknown physical conditions of an unusual nature, differing materially from those ordinarily encountered and generally recognized as inherent in the Work provided for in the Contract Documents are encountered at the Project site, the Contractor shall notify the Engineer, in accordance with the process and timeline set forth in 104.03, before the conditions are disturbed or the affected Work is performed.

Upon notification, the Engineer will investigate the conditions to determine whether (i) the conditions meet the requirements of a differing site condition as defined herein, and (ii) cause an increase or decrease in the cost and/or time required for the performance of any Work under the Contract.

The Engineer will notify the Contractor in writing whether the condition is determined to be a differing site condition as defined herein. If the Engineer determines that there is a differing site condition, the City will adjust the Contract as specified in 108.06 and 109.05.

If the Contractor disagrees with the Engineer's determination, the Contractor must provide notice and bring a Claim in accordance with the process and timeline set forth in 104.03.

C. Written Delay or Suspension of Work. The Engineer may direct the Contractor, in writing, to delay its start of operations or to suspend its operations for the length of time that the Engineer deems necessary.

If the performance of all or any portion of the Work is delayed or suspended by the Engineer, in writing, for an unreasonable period of time (i.e. a period of time not originally anticipated, customary, or inherent to the construction industry or the Work involved) and the Contractor believes that additional compensation or time is due as a result of such delay or suspension, the Contractor must provide notice and bring a Claim in accordance with the process and timeline set forth in 104.03.

The Engineer will evaluate the Contractor's request in accordance with 104.03. If the Engineer agrees that the cost and/or time required for the performance of the Work has increased as a result of an unreasonable delay or suspension and such delay or suspension was caused by conditions beyond the control of and not the fault of the Contractor, its subcontractors at any tier, or its suppliers, the Engineer will notify the Contractor in writing and the City will adjust the Contract as specified in 108.06 and 109.05; provided, however, the City will not make an adjustment under this Section in the event that the Contractor's performance is delayed or suspended by any other cause or for which a Contract adjustment is provided or excluded under any other term or condition of the Contract.

If the Contractor disagrees with the Engineer's determination, the Contractor must provide notice and bring a Claim in accordance with the process and timeline set forth in 104.03.

D. Significant Changes in Character of the Work. The City may increase or decrease quantities and alter the Work as necessary or desirable to complete the Project.

The Engineer will make appropriate adjustments to the Contract in accordance with 108.06, 109.04, and 109.05, if such alterations constitute a significant change in the character of the Work. A "significant change" as used in this Section is defined as:

1. When the character of the Work as altered differs materially in kind or nature from that involved or included in the original Contract, or
2. Where the quantity of a Unit Price pay item in the Contract is an estimated quantity and when the actual quantity of such pay item varies more than twenty-five percent above or below the estimated quantity stated in the Contract. An adjustment in the Contract Price for such a pay item may be made in accordance with 109.04 upon demand of either party.

If a quantity variation in excess of 125% of the estimated quantity also causes an increase in the Contract Time(s), the Contractor shall demonstrate the time impact, if any, by an analysis in accordance with 108.03 and in accordance with the requirements of 108.06. If the Engineer concludes that the Contract Time(s) should be adjusted as a result of such quantity overrun, the City will issue a Change Order to adjust the Contract Time(s) as the Engineer determines.

The Contractor shall give the Engineer prompt written notice when it is aware, or has reason to believe, that quantities will overrun or underrun by 25% or more of the estimated quantity so that the City will have the opportunity to mitigate the effect, if any, on the scope, cost or time of the Project. This notice obligation shall be in addition to any notice of claim for additional compensation or time pursuant to 104.03.

If the Contractor believes that an alteration constitutes a significant change as defined by this Section, the Contractor must provide notice and bring a claim in accordance with the process and timeline set forth in 104.03. If the City believes that there has been a significant change as defined by this Section, the City shall provide written notice to the Contractor that it is seeking an adjustment of the Contract Sum or Time, which shall be determined in accordance with 109.04.

The unit prices for the following items are not subject to adjustment under 104.02.D:

1. Contingency;
2. Allowances;
3. Erosion Control items under Item 207; and
4. Any other item not bid by the Contractor.

E. Eliminated Items. Should any items contained in the Contract be found unnecessary for the proper completion of the Work, the Engineer may, upon written deductive Change Order to the Contractor, eliminate such items from the Contract, and such action shall in no way invalidate the Contract.

The pricing adjustment for any eliminated items of Work shall be determined according to 109.04.

If the Contractor disagrees with the Engineer's determination, the Contractor must provide notice and bring a Claim in accordance with the process and timeline set forth in 104.03.

F. Extra Work. The Engineer may direct the Contractor to perform Extra Work.

If the Extra Work will result in an increase in the Contract Sum or Time, the City shall have the right to require the performance thereof on a lump sum basis.

If the City elects to have the Extra Work performed on a lump sum basis, the Contractor shall submit to the Engineer a proposal for such change within ten days of the Contractor's receipt of a Request for Proposal (RFP). The Contractor's response to the City's RFP shall be itemized and segregated by labor, materials, equipment, subcontractors, supplies and appurtenances for various components of the change in the Work and shall be accompanied by signed proposals of any subcontractors that will perform any portion of the change in the Work and of any suppliers that will furnish materials or equipment for incorporation therein. Pricing of the Extra Work shall be done in accordance with 109.05.C. The proposal shall also include the Contractor's estimate of any impact to the Project's critical path as shown on the last accepted progress schedule at the time of the proposal or any non-critical path changes to the accepted progress schedule that may be required to perform the proposed change.

The Contractor, subcontractors and suppliers shall assure that the costs, pricing and schedule data submitted for evaluation with the Contractor's proposal are based on current, accurate and complete data supported by their books and records. If the City later determines that any cost or time negotiated in connection with the Extra Work decreased by any material amount because the data provided was incomplete, inaccurate or not current at the time of submission, then such price or time shall be reduced accordingly and the Engineer shall issue a written Change Order to reflect such action. Failure to agree on a reduction shall be subject to the Unilateral Change Order provisions of this Contract.

In the event that the Contractor fails to submit its proposal in response to the City's RFP within the designated ten day period, or in the event that the parties are unable to agree as to the reasonable cost and time to perform the change, the Engineer shall either direct the Contractor to perform the Extra Work on a Force Account Basis in accordance with 109.05.C, or shall make a determination of the reasonable cost and time to perform the Extra Work, based upon its own estimate, the Contractor's submission (if any), or a combination thereof.

Failure of the parties to reach agreement regarding the cost and time of performing the Change Order or any pending Claim shall not relieve the Contractor from performing the Extra Work promptly and expeditiously as directed by the Engineer.

The City will determine whether a time extension related to Extra Work is warranted in accordance with 108.06.

If the Contractor believes that any Work it is performing is Extra Work as defined by the Contract, the Contractor must provide notice and bring a Claim in accordance with the process and timeline set forth in 104.03.

G. Unilateral Change Orders. In the event that the City and Contractor are unable to agree as to the reasonable cost and time to perform Extra Work, the City has the authority to direct the Contractor to perform the Extra Work. The City will issue a Unilateral Change Order to the Contractor for any cost or time it determines to be due to the Contractor in connection with the Extra Work performed on the Project.

The issuing of a Unilateral Change Order by the City will not preclude or limit the rights of City and Contractor to negotiate and agree to the amounts to be paid or time extension given to the Contractor.

If the Engineer issues a Unilateral Change Order directing a change for the amounts of cost and/or time determined by the Engineer, it shall become binding upon the Contractor unless the Contractor submits a Claim in accordance with the process and timeline set forth in 104.03. If the

Contractor does not submit a timely Notice of Claim, the Contractor shall be deemed to be in agreement with the Unilateral Change Order as issued and the Contractor expressly waives its right to contest such Change Order, including the amount of cost and/or time provided therein.

H. Minor Changes/Clarifications to the Work. The Engineer shall have authority to issue Field Orders for minor changes or clarifications to the Work. The Contractor shall carry out such Field Orders promptly and as directed by the Engineer. Such Field Orders shall be considered incidental to the Work.

104.03 Contractor Notification, Continuation of Work, and Claims.

A. General. The Contractor shall provide timely notice and complete the Claim resolution process as provided in this Section as a condition precedent to filing an action in the Franklin County Court of Common Pleas seeking additional compensation or time. The Contractor's failure to provide timely notice or meet any of the timeframes set forth below, or to request and receive written agreement from the City for an extension of such timeframes, shall terminate further review of the Claim and shall be deemed to be a waiver and release of the Contractor's right to pursue the Claim. Without limiting the generality of the foregoing, the City will not make the adjustments allowed by 104.02.B through 104.02.F if the Contractor did not give notice as specified in this Section; provided, further, no Claim may be made after the City makes final payment under this Contract.

In addition to any specific notice requirements set forth elsewhere in the Contract, if the Contractor believes that any event or circumstance or action or inaction of the City gives the Contractor the right to additional compensation or time, it shall provide timely notice and complete the Claim resolution process as provided in this Section.

B. Notice

1. Initial Oral Notification. The Contractor shall provide immediate oral notification to the Engineer upon discovering an event or circumstance that may require a modification to the Contract Documents or may result in a claim for additional compensation and/or time. Upon such notification, the Engineer will attempt to resolve the identified issue as quickly as possible. The Contractor is advised that oral notice must be followed up by a written notice as provided in 104.03.B.2 in order for the Contractor to preserve its right to make and pursue a Claim; if the Contractor fails to do so, it shall be a waiver and release of the Claim.

2. Written Notice. If the issue has not been resolved, the Contractor must submit Written Notice no later than five working days after the Initial Oral Notification stating that the event or circumstances may require a modification to the Contract Documents or may result in a Claim for additional compensation and/or time. The written notice shall contain:

a. A description of the circumstance giving rise to the Claim or the potential Claim, including the time, date and location the event or circumstance was first identified.

b. An explanation why the event or circumstance represents a change to the Contract, with reference to the pertinent sections or parts of the Contract Documents.

c. An estimate of the revisions considered necessary to the Contract Sum or Time.

d. An estimate of the time within which the City needs to respond to the notice in order to minimize or mitigate additional cost or delay to the Project.

e. As to any Claim on which the Contractor has provided written notice, it shall from the date of the written notice keep books and records of labor, equipment and materials detailing any costs or delays associated with such claim or the circumstances giving rise to the claim or potential claim. The keeping of such books and records shall be done in accordance with 109.05.C.8 and the Contractor acknowledges and agrees that the City's participation in this recordkeeping process and acceptance of those records is solely for recording costs incurred and not an acknowledgment of the merit, if any, of a Claim for additional compensation or time, which shall be determined in accordance with the process set forth in this Section. Because of its preliminary nature, the City will require only the Contractor's best estimate based on available information at the time of first written notice; provided, however, the Contractor shall keep the Engineer regularly informed in writing of any on-going cost or time issues and shall, within thirty days after the end of the Claim event or circumstances, supplement its prior submissions identified as its final cost and time information, as applicable.

C. Continuation of Work. The Contractor shall continue with all Work, including the Work that is the subject of a Claim or potential Claim, unless specifically directed otherwise by the Engineer. The City shall continue to pay the Contractor for all non-disputed work performed during the pendency of any Claim.

D. Claims. Claims by subcontractors and suppliers may be pursued by the Contractor on behalf of subcontractors or suppliers if and to the extent the Contractor is entitled to relief under the Contract. Any Claims brought by the Contractor, on behalf of itself or any subcontractor or supplier, shall be subject to all requirements of this Section.

The Contractor shall provide with each Claim a Certification of Claim that:

1. The Claim is made in good faith and is fully documented and supported in accordance with the terms of the Contract.

2. The supporting data is accurate and complete to the best of the Contractor's knowledge and belief after appropriate inquiry and review.

3. The Claim amount or time requested accurately reflects the Contractor's actual incurred costs or additional time, or its best estimate of costs or additional time to be incurred if it is not known at the time the Claim is made. (In the event an estimate is provided initially, the Contractor will be required to re-certify, as provided herein, the accuracy of the Claim when the final costs and time are presented to the City.)

4. Acknowledgement by the signatory that the Certification is signed under penalty of law for perjury or falsification with specific reference to the City's False Claim provision in Section 335.05 of City Code.

E. Dispute Resolution Process.

1. Step 1 (On-Site Determination). Within five calendar days of receipt of the Contractor's Written Notice as required under 104.03.B.2, the Engineer will meet with the Contractor's representative(s) to review all pertinent information and contract provisions and negotiate in an effort to reach a resolution in accordance with the Contract Documents. Within fourteen calendar days of the Step 1 meeting, the Engineer will issue a written Step 1 decision describing the decision and reasoning for it. If the dispute is not resolved at Step 1, the Contractor must either abandon the Claim or continue pursuing the Claim by proceeding to Step 2 within the required timeframe.

These time-frames may be extended by the Engineer, in writing, as needed for the Contractor to provide merit, cost and time information regarding the dispute, as requested by the Engineer.

2. Step 2 (Claim Resolution Committee). Within seven calendar days of receipt of the Step 1 decision, the Contractor must submit a written request for a Step 2 meeting to the Director. The Director will promptly establish within the applicable City Department, and Division if applicable, a Claim Resolution Committee (CRC). Within fourteen calendar days after the Director's receipt of the Contractor's request for a Step 2 meeting, the Contractor shall submit (or supplement) documentation that describes the Claim, the monetary amount or time extension sought, the basis for Contractor's Claim under the Contract Documents, and copies of any applicable parts of the Contract Documents and project records, all in accordance with 104.03.B.2.

Within fourteen calendar days after receipt of the Contractor's documentation, the Engineer will send to the Contractor and the CRC his/her written response. Within fourteen calendar days after receipt of all documentation, the CRC will meet with the Contractor and the Engineer (or designee) to discuss the Claim.

If the Claim is not resolved at the meeting, within fourteen calendar days after the meeting, the Director will issue to the Contractor a written decision.

The time periods under this Section may be revised by written approval of the Director.

3. Alternative Dispute Resolution (ADR). If the Contractor does not accept the Director's Step 2 decision, within fourteen calendar days of its receipt of the Step 2 decision, the Contractor may submit to the Director a written Notice of Intent to Pursue a Claim.

The Contractor's Notice of Intent to Pursue a Claim shall advise the Director whether the Contractor wishes to resolve the Claim using either mediation or arbitration.

If the Contractor proposes mediation, within thirty calendar days after receipt of the Contractor's Notice of Intent to Pursue a Claim, the Director shall advise the Contractor in writing whether the City accepts the Contractor's proposal.

If the Contractor proposes arbitration, it shall be subject to approval of the City Council or such other conditions that are necessary to comply with City Code. Within thirty calendar days after either the City Council acts on the matter or the Contractor advises the Director that it will accept any conditions that are necessary to comply with City Code, the Director shall advise the Contractor in writing whether the City accepts the Contractor's proposal to arbitrate.

If the City accepts using mediation or arbitration, the parties will use the then applicable International Institute for Conflict Prevention and Resolution Mediation Procedure or the International Institute for Conflict Prevention and Resolution Rules for Expedited Arbitration of Construction Disputes, as applicable. The parties will enter into such further agreement as is necessary to implement the ADR process selected and may make modifications to such processes as they mutually agree.

4. Filing of Lawsuit in Franklin County Court of Common Pleas. If the Claim is not resolved at Step 2 and the Contractor does not elect to request ADR pursuant to 104.03.E.3 or the City declines the Contractor's request for an ADR process pursuant to 104.03.E.3, the Contractor must either abandon the Claim or file a lawsuit in the Franklin County Court of Common Pleas within one hundred twenty calendar days after receipt of the Director's Step 2 decision. The Contractor's failure to file a lawsuit within that time period shall be deemed a waiver and release of the Claim against the City. The time period to file a lawsuit may be extended by mutual written agreement of the City and the Contractor.

104.04 Maintenance of Traffic and Accessibility to Utilities. The Contractor shall at all times provide and maintain access to fire hydrants, water valves, water service boxes, gas valves, gas service boxes, manholes and other similar appurtenances.

When so stated in the Contract Documents, maintain public traffic during construction, including cross traffic at intersections. Maintenance of traffic may be required only at certain stages of construction or at all times, if so noted.

At locations on the Project where only sewer or water line construction is called for and a part of the existing pavement will remain in place, maintain traffic and provide ingress and egress to all public and private entrances.

In the event of the complete closure of any street, alley or private drive, the Contractor shall give written notification to the occupants of all premises affected by such closure as per Item 614 – Maintaining Traffic.

If the Contractor, for any reason within its control, ceases operations on the Contract for a period of fourteen or more calendar days, the Contractor, if so directed by the Engineer, shall construct a temporary roadway to provide access to any premises affected by Project operations. The temporary roadway shall be constructed of acceptable materials and of suitable width and thickness to carry anticipated vehicles, as directed by the Engineer. The Contractor shall maintain the temporary road in serviceable condition until such time that the Work is resumed. The Contractor shall bear the cost of constructing, maintaining, and removing any temporary roadway.

Failure of the Contractor to perform the operations stated in this Section when directed by the Engineer, within the timeframe provided by the Engineer, will give the City authority to perform the work and back charge such cost to the Contractor.

The Contractor shall furnish, erect, maintain and remove all traffic control devices in accordance with the OMUTCD. All traffic control devices shall be paid for in accordance with the provisions of Item 614. When the Contract Documents do not include Item 614, the cost of this work shall be included in the price bid for various items in the Proposal. The provision of these items and this Section shall not in any way relieve the Contractor of any of its legal responsibilities or liabilities for the safety of the public. The attention of the Contractor is also directed to the provisions of 107.02 and 107.07 of the Specifications.

104.05 Rights In and Use of Materials Found on the Work Site. If the Contractor proposes that existing raw or recycled Materials Found on the Work Site are compliant with the specifications for the Work, the Contractor may submit an add/deduct cost proposal to the Engineer for consideration. The Contractor shall also indicate if there are add/deduct time adjustments to the contract completion time associated with the use of these materials. All portions of suitable or unsuitable excavation material removed, which was needed for use in the embankments, backfills, approaches, or otherwise, shall be replaced with other acceptable material, at the expense of the Contractor. Excavate or remove material only from within the grading limits, as indicated by the slope and grade lines.

104.06 Right of Property in Materials. All materials attached, fixed or incorporated into the Work or the soil shall thereupon become property of the City and the Contractor shall have no property rights thereto.

104.07 Final Cleaning Up. Before Final Acceptance, remove all rubbish, layout stakes, monitoring wells, settlement instrumentation devices, sediment control devices as directed by the Engineer, excess material, temporary structures, and equipment, including stream channels and banks within the Right-of-Way at drainage structures, and all borrow and waste areas, storage sites, temporary plant sites, haul roads, and other property occupied by the Contractor in connection with the Work. Establish suitable vegetative cover in these areas by seeding and mulching or sodding according to Items 659 or 660, except for cultivated fields. Leave the Project site in an acceptable condition as determined by the Engineer. Unless a separate bid item is provided in the Proposal, the cost of cleanup is incidental to all Contract Items.

104.08 Recordkeeping/Audit. The Contractor, subcontractor(s) and supplier(s) shall cooperate with the City and shall produce, compile, maintain and keep all cost, time and schedule records sufficient to substantiate all requests for payment, Claims for additional compensation, and requests for time extensions. The Contractor shall keep the following records, including but not limited to, daily time sheets and foreperson's daily reports, union agreements if any, payroll register, earnings records, payroll tax returns, material invoices, purchase orders, cancelled checks, equipment records, vendor rental agreements, subcontractor payment certificates, job cost report, general ledgers and subsidiary ledgers, cash disbursement journals, complete bid estimate and worksheets, financial statements, worksheets used to prepare the Claim and establish cost components for Claim items, and schedule information and updates.

Upon reasonable written notice to the Contractor, the City or its designated agents shall be provided access to, and the right to inspect and audit, all of the Contractor's and its subcontractors' and suppliers' records pertaining to the Project without cost to the City. If and to the extent that the Contractor fails to maintain and keep proper Project records, fails to provide the City or its designated agents access to such Project records, or fails to provide the documentation required by Item 108 or 109, the City may deny any requests for payment, additional compensation, and/or requests for time extensions if and to the extent they have not been or cannot be substantiated by the Contractor or by inspection/audit of the City.

ITEM 105 CONTROL OF WORK

105.01 Authorities and Duties
105.02 Plans and Working Drawings
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105.01 Authorities and Duties.

A. Authority of the Director. The Director has the authority to enter into a Contract or execute a Contract Modification subject to the applicable provisions of the Columbus City Code and City Charter. The Director has the authority, on behalf of the City, to delay or terminate the Contract,

and to suspend Work wholly or in part. The Director has the ultimate decision making authority over all items included under the authority and duties of the Engineer.

Any action or inaction of the Director does not constitute a waiver of the City's right to pursue any and all remedies under the Contract or otherwise, including, but not limited to, defective work or Work performed by the Contractor in an unworkmanlike manner.

B. Authority and Duties of the Engineer. The Engineer has immediate charge of the engineering details of the Project and is responsible to ensure that the Contractor satisfactorily administers and completes the Work. The Engineer will decide all questions that may arise as to:

1. The quantity, quality and acceptability of materials furnished;
2. The quantity of work performed and the Contractor's rate of progress;
3. Conformity with Plans, Specifications and other Contract Documents;
4. Acceptable fulfillment of the Contract on the part of the Contractor;
5. Interpretation of the Plans, Specifications and other Contract Documents; and
6. Contractor's compensation and/or time extensions.

The Engineer may suspend all or part of the Work pursuant to 104.02.C. In addition, the Engineer may also suspend all or part of the Work when the Contractor fails to correct conditions that are unsafe for the workers or the general public, fails to comply with the Contract Documents, or fails to comply with the Engineer's orders. The Engineer may suspend the Work due to adverse weather conditions, conditions considered adverse to the prosecution of the Work, or other conditions or reasons in the public interest. The suspension of the Work for the reasons specified in this paragraph shall not relieve the Contractor of the responsibility to take appropriate actions to protect the Project site, adjacent property owners, and general public. In the event the Engineer orders the Work suspended for conditions under this paragraph, the expense and time, whether direct or indirect, for such suspension, shall be borne solely by the Contractor and shall not be considered a suspension of work under 104.02.C.

Any action or inaction of the Engineer shall not constitute a waiver of the City's right to pursue any and all legal remedies under the Contract or otherwise, including, but not limited to, defective or non-conforming work or work performed by the Contractor in an unworkmanlike manner.

C. Authority and Duties of the Inspector. Inspectors employed by the City are authorized to judge the acceptability of the Work. Such activities may extend to all or any part of the Work and to the preparation, fabrication or manufacture of the materials to be used. The Inspector is not authorized to alter or waive the provisions of the Contract, but shall have the authority to notify the Contractor of Work that does not conform to the Contract or reject materials that do not conform to the Specification requirements. The Inspector is not authorized to issue instructions contrary to the Plans and Specifications, or to act for the Contractor. The presence of or actions or inactions by the Inspector shall not relieve the Contractor of the responsibility to complete the Work under the terms and conditions of the Contract Documents.

Any action or inaction of the Inspector does not constitute a waiver of the City's right to pursue any and all legal remedies under the Contract or otherwise, including, but not limited to, defective or non-conforming work or work performed by the Contractor in an unworkmanlike manner.

105.02 Plans and Working Drawings. The Contractor shall be responsible for the furnishing of copies of Plans, Specifications, Supplemental Specifications, and Special Provisions, or the necessary portions thereof, to subcontractors and parties furnishing labor, materials and equipment for the Project.

The Contractor shall prepare Working Drawings and submittals when required by the Contract Documents and after verifying applicable field and plan elevations, dimensions, geometries, and conditions. Working Drawings shall be detailed as required to adequately control and complete the Work. When specified, Working Drawings must be stamped by a Registered Professional Engineer in the State of Ohio. Where Work consists of repairs, extension, or alteration of existing structures, the Contractor shall take measurements of existing structures to accurately join old and new Work. Any measurements that may appear upon the Plans to indicate the extent and nature of such repair or extension shall not relieve the Contractor of this responsibility.

Unless otherwise indicated, the Engineer will review submittals for the limited purpose of checking conformance with the Contract Documents and to provide the Contractor a written response to document the results of its review.

The Engineer's disposition shall not relieve the Contractor of responsibility to complete the Work according to the Contract Documents, including but not limited to, the accuracy and reliability of Working Drawings furnished by the Contractor. The Contractor shall include the cost of furnishing Working Drawings in the cost of the Work they cover.

105.03 Conformity with Contract Documents. All Work performed and all materials furnished shall be in reasonably close conformity with the lines, grades, cross sections, dimensions and material requirements, including tolerances, shown on the Plans or indicated in the Specifications.

Unless otherwise stated in Special Provisions or in a Plan note, the latest revision of any applicable Federal, State, City, or industry code, regulation, or standard at the time of bid opening shall apply. Codes and regulations shall take precedence over industry standards.

Without detracting from the complete and absolute discretion of the Engineer to insist upon such tolerances as establishing reasonably close conformity, the Engineer may accept variations beyond such tolerances as reasonably close conformity where they will not materially affect the value or utility of the Work and the interests of the City. In the event the Engineer finds the materials or the finished product in which the materials are used not within reasonably close conformity with the Plans and Specifications but that reasonably acceptable work has been produced, the Engineer shall then make a determination if the Work shall be accepted and remain in place. In this event, the Engineer will document the basis of acceptance by deductive Change Order which will provide for an appropriate adjustment in the Contract Sum for such work or materials as is deemed necessary to conform to the determination based on the Engineer's judgment.

In the event the Engineer finds the materials of the finished product in which the materials are used or the Work performed are not in reasonably close conformity with the Plans and Specifications and has resulted in an inferior or unsatisfactory product, the work or materials shall be removed and replaced or otherwise corrected by and at the expense of the Contractor. Failure of the Contractor to follow such order of the Engineer shall give the City the unqualified right to remove and replace the unsatisfactory Work, supply the materials for the finished Work, and perform the Work or cause it to be performed, and any and all expense chargeable thereto, directly or indirectly, shall be deducted or billed to the Contractor at the option of the Engineer pursuant to 109.14.

105.04 Coordination of the Contract Documents. The Contract, Specifications, Supplemental Specifications, Plans, Special Provisions, Proposal, Standard Drawings and all supplementary documents are essential parts of the Contract Documents, and a requirement occurring in one is as binding as though occurring in all. They are intended to be complementary and to describe and provide for a complete Work.

In case of discrepancy, the Engineer will resolve any discrepancies using the following descending order of precedence:

A. Contract Form

B. Addenda

C. Proposal Form and Special Provisions

D. Plans (Calculated dimensions on the Plans will govern over scaled dimensions.)

E. Technical Specifications

F. Supplemental Specifications and Supplements

G. Standard Drawings

H. Specifications (CMSC)

The Contractor shall take no advantage of any apparent error or omission in the Contract Documents. In the event the Contractor discovers such an error or omission, it shall immediately be made known to the Engineer in writing. The Engineer will then make such corrections and interpretations as may be deemed necessary for fulfilling the intent of the Contract Documents.

105.05 Cooperation by Contractor. The Contractor shall give the Work the constant attention necessary to facilitate the progress thereof, and shall cooperate in every possible way with the Engineer, Inspectors, all other Contractors on or adjacent to the Project, and all utility companies and railroads. The Contractor shall attend progress meetings when requested by the Engineer. The Contractor shall keep at least one set of Contract Documents at the Project at all times.

Where the Work extends across private property, the Contractor shall conduct operations in strict conformity with the terms and conditions of the easements and agreements obtained from the owners of the property. The City will not provide any points of access to any of these easements other than at points shown or described in the easement or agreement with the property owner. Arrangements for the use of any additional points of access shall be made with the property owners by the Contractor at no additional cost, or obligation, to the City.

The Contractor agrees to confine the work under the Contract to the strict dimensions of Construction Limits. Any failure of the Contractor, or the Contractor's agents, employees and subcontractors, to restrict the Work within the Construction Limits, shall be the sole liability and responsibility of the Contractor, and the Contractor shall defend, indemnify and hold harmless the City as provided in 107.24 relating to any activity of the Contractor's agents, employees and subcontractors where such activity concerning Work under this Contract extends beyond the Construction Limits. The Contractor also agrees that where its operations extend outside the Construction Limits, the Engineer has the absolute right to suspend the applicable Work, unless the Contractor provides written evidence that indicates permission from the property owner.

In the event the Engineer orders the Work suspended for conditions under this Section, the expense and time, whether direct or indirect, for such suspension shall be borne solely by the Contractor and shall not be considered a suspension of work under 104.02.C.

If the Contractor disperses any or all of its equipment to an area outside the Construction Limits of the Project, the re-mobilization of the equipment back to the work area shall be at the Contractor's expense.

105.06 Superintendent. Provide a competent Superintendent for the Project that is available and responsive at all times and is responsible for all aspects of the Work. The Superintendent must be capable of reading and understanding the Contract Documents and experienced in the type of Work being performed. The Superintendent shall receive instructions from the Engineer or the Engineer's authorized representatives. The Superintendent shall have the full authority to execute the Engineer's orders or directions without delay and to promptly supply the required materials, equipment, tools, labor and incidentals. Such superintendence shall be furnished irrespective of the amount of Work sublet.

105.07 Cooperation with Utilities.

A. General. During the course of design, the City shall notify all utility companies, all pipeline owners or other parties affected and endeavor to have all necessary adjustments of the public or private utility fixtures, pipe lines and other appurtenances within or adjacent to the Construction Limits made as soon as possible so as not to interfere with the progress of the Work or in accordance with the time provisions set forth in the Contract Documents.

The Contractor shall comply with all laws, regulations and codes concerning the identification and locations of all underground utilities. During the course of the Work, the Contractor shall be solely responsible to notify any utility or other service when such utility or service is encountered.

Water lines, gas lines, wire lines, service connections, water and gas meter boxes, water and gas valve boxes, light standards, cable-ways, signals, and all other utility appurtenances within the limits of the proposed Construction Limits which are to be relocated or adjusted are to be moved by the utility owners at their expense, except as otherwise provided for in the Special Provisions or as noted on the Plans.

If the Contractor is directed by a utility company to perform any work not specifically contained in the Plans, the City will not compensate the Contractor for this work unless the City approves the request in writing before the work begins. If the work is not preapproved by the City, the Contractor will be responsible for obtaining reimbursement for its work from the utility company which directed the Contractor to perform the work.

In the event that the Contractor requests that additional work, not specifically contained in the Plans, be performed by a utility company, the Contractor will be responsible for reimbursing the utility company for the additional work unless the City has agreed in writing to pay for the additional work before the work begins.

B. Protection and/or Replacement of Utilities. The Contractor shall protect all utilities encountered while performing the Work, whether indicated on the Plans or not. The Contractor shall exercise due care when excavating around utilities and shall restore any damaged utilities to the same condition or better as existed prior to starting the Work, at no cost to the City.

C. Surface or Overhead Utilities. Existing surface or overhead structures or utility lines are not necessarily shown on the Plans and those shown are only approximately correct. The Contractor shall make such investigations as are necessary to determine the extent to which existing surface or overhead structures may interfere with the prosecution of the Work contemplated under the Contract Documents.

D. Subsurface Utilities. The information and data shown or indicated in the Contract Documents with respect to existing subsurface utilities at or contiguous to the Construction Limits is based on information and data furnished to the City by the owners of such subsurface utilities, including the City, or by others.

The City shall not be responsible for the accuracy or completeness of any such information or data provided by others.

The cost of all of the following shall be included in the Contract Sum, and the Contractor shall have full responsibility for:

1. reviewing and checking all such information and data;
2. determining the exact location of all subsurface structures and utilities (including sewer service connections) shown or indicated in the Contract Documents;
3. coordination of the Work with the owners of such subsurface utilities, including the City, during construction; and
4. the safety and protection of all such subsurface utilities and repairing any damage thereto resulting from the Work.

In accordance with Section 153.64 of the Ohio Revised Code, at least two Working Days, excluding Saturdays, Sundays, and legal Holidays, but no more than ten working days, prior to commencing construction operations in the construction area which may involve underground utility facilities, the Contractor or its subcontractor(s) shall notify the registered utility protection service and the owners of each underground and overhead utility facility not members of the registered utility protection service.

If a subsurface utility is uncovered or revealed which was not shown or indicated, or not shown or indicated with reasonable accuracy, in the Contract Documents, the Contractor shall, promptly after becoming aware thereof and before further disturbing conditions affected thereby or performing any Work in connection therewith, identify the owner of such subsurface utility and give written notice to that owner and to the City. The Engineer will promptly review the subsurface utility and determine the extent, if any, to which a change is required in the Contract Documents to reflect and document the consequences of the existence or location of the subsurface utility. During such time, the Contractor shall be responsible for the safety and protection of such subsurface utility.

E. Delay. In the event that the Contractor has used reasonable efforts to coordinate with a utility company to relocate or adjust its lines and, through no fault of the Contractor, the progress of the Work is delayed for an unreasonable length of time from that shown in the accepted progress schedule due to the failure of a utility company to relocate or adjust its lines, the Contractor shall immediately file with the City a detailed statement describing the nature of the delay and its effect upon progress of the Work and shall be entitled to request a Contract adjustment in accordance with 104.03 and 108.06.

F. Utility Shut-off. In the event that the Work requires a shut-off of any public or private utilities, the Contractor shall notify the affected subscribers of the time of such shut-off and the probable time that service will be restored. The Contractor shall make such notification at least forty eight hours prior to such shut-off unless otherwise directed by the Engineer. If a shut-off is cancelled or postponed, the Contractor shall notify the affected subscribers of the new time of shut-off and the probable time that service will be restored.

All shut-offs and turn-ons shall be made under the direction and supervision of personnel of any affected utilities and the Contractor shall furnish all assistance required including tools and equipment. The time and place of such shut-offs shall be designated by the Engineer.

G. Basis of Payment. It is understood and agreed that the Contractor has considered in the Proposal all permanent and temporary utility appurtenances in their present or relocated positions and included the cost thereof in the price bid for the various items in the Contract. No additional compensation shall be allowed for any delays, inconvenience, or damage sustained by the Contractor due to any interference from such utility appurtenances or the operation of moving them, except as provided for in 104.02.B, if applicable.

H. Indemnification. The Contractor shall defend, indemnify and hold harmless the City as provided in 107.24 relating to any damage caused by the Contractor or its agents, assigns or employees, or by the Contractors' subcontractor(s), done directly or indirectly to the above mentioned items, whether such damage results from negligence or otherwise and whether the damage is to private or public property or real or personal property. The Contractor hereby agrees that it bears the sole responsibility to pay the entire cost thereof.

Failure of the Contractor to pay the entire cost as stated above within thirty days shall give the Director the unqualified right to deduct and withhold the entire amount of damages from the cost of this Contract.

The Contractor further covenants not to sue the City, either in law or equity, where such deduction and withholding is made by the City.

The City shall return, within a reasonable time thereafter not to exceed thirty days, any excess amount over the amount of damages paid by the City or judgments and costs of litigation the City is required to pay.

The Contractor further waives any and all rights, title or interest in any and all amounts so liquidated and any and all amounts of judgments and costs of litigation found against the City.

105.08 Cooperation between Contractors. The City reserves the right at any time to contract for and perform other work on or near the Work covered by the Contract.

When separate contracts are awarded within the work limits of any one project, each Contractor shall conduct its work so as not to interfere with or hinder the progress or completion of the work being performed by other Contractors. Contractors working on the same project shall cooperate with each other as directed by the Engineer.

Each Contractor involved shall assume all liability, financial or otherwise, in connection with its Contract and shall defend, indemnify and hold harmless the City as provided in 107.24 relating to any inconvenience, delay, or loss relating to the presence and operations of other Contractors working within the limits of the same project.

The Contractor shall arrange its work and shall place and dispose of the materials being used so as not to interfere with the operations of the other Contractors within the limits of the same project. Each Contractor shall join their work with that of the others in an acceptable manner and shall perform it in proper sequence to that of the others.

105.09 Construction Stakes, Lines and Grades. Unless the Proposal contains a Lump Sum bid Item 623 Construction Layout Stakes, the Contractor shall execute all Work in conformity to the lines and grade furnished by the City and shall preserve all points of reference until authorized to remove them. The Contractor shall notify the City at least two working days prior to the time that stakes or other points for line and grade will be needed. There shall be no compensation to the Contractor for the cost occasioned by delay in establishing lines, grades and elevations or making other necessary measurements or by inspection; but such costs shall be considered as having been included in the Contract Price.

Perform all construction staking, including privately funded projects, under the supervision of a Registered Professional Engineer or Land Surveyor. Submit all field notes, cut sheets, etc., to the City upon request.

105.10 Photographs and Videos. The Engineer, Inspectors or other duly authorized City personnel or agents, during the progress of the Work, may take photographs or videos of the Work. The Contractor shall furnish access to the Work at all times for this purpose and shall furnish such assistance as may be required. The photographs or videos thus taken shall be the property of the City. Nothing herein contained shall be construed as prohibiting the taking of photographs or videos by the Contractor or its agents, provided, however, that it is done at no cost or expense to the City.

105.11 Inspection of Work. All materials and each part or detail of the Work shall be subject to inspection by the Engineer, Inspector or duly authorized City representative. Inspection by the Engineer, Inspector, or other duly authorized City representative does not relieve the Contractor of performance in accordance with the Contract Documents. The Engineer, Inspector or duly authorized City representative shall be allowed access to all parts of the Work and shall be furnished with such information and assistance by the Contractor as is required to make a complete and detailed inspection. Notify the Engineer at least twenty four hours prior to all required special inspections and testing as specified in the Contract Documents or as required by the Engineer.

If the Engineer requests it, the Contractor, at any time before acceptance of the Work or any portion thereof, shall remove or uncover such portions of the finished Work as may be directed. After examination, the Contractor shall restore said portions of the Work to the standard required by the Contract Documents. Should the Work thus exposed or examined prove acceptable, the uncovering, or removing, and the replacing of the covering or making good of the parts removed, will be paid for as Extra Work; but should the Work so exposed or examined prove unacceptable, the uncovering or removing and the replacing of the covering or making good of the parts removed, shall be at the Contractor's expense.

The Contractor shall notify the Engineer at least forty-eight hours in advance of any changes in the work schedule. This notification is required to accommodate construction inspection scheduling. The notification shall include the beginning date and time of the work, and the duration of the work. The notification shall be submitted to the Engineer in writing. In the absence of such notification, and if the work is performed without inspection, the Engineer may require the work to be removed and redone.

If the City assigns an inspector(s) to the project and the Contractor does not notify the City of its intent not to work, charges incurred by the City for inspection services will be deducted from monies owed to the Contractor/Developer, unless such charges are waived by the Director.

Any Work done or materials used without supervision or inspection by an authorized City representative may be ordered removed and replaced at the Contractor's expense. Failure to reject any defective Work or materials shall not in any way prevent later rejection when such defects are discovered, or obligate the City to final acceptance of the Work.

When any unit of government or political subdivision or railroad or any corporation is to pay a portion of the cost of the Work covered by this Contract, its respective representatives shall have the right to inspect the Work. Such inspection shall not make any unit of government or political subdivision or railroad or any corporation a party to this Contract, and shall in no way interfere with the rights of the Contractor or City hereunder.

105.12 Removal of Unacceptable and Unauthorized Work. All Work that does not conform to the requirements of the Contract Documents may be considered unacceptable Work.

Unacceptable Work, whether the result of poor workmanship, use of defective materials, damage through carelessness, or any other cause, found to exist prior to the expiration of the guaranty period, shall be removed immediately and replaced in a manner acceptable to the Engineer at no expense to the City.

Work done contrary to the instructions of the Engineer, Work done beyond what is shown in the Contract Documents, or any Extra Work done without authority, will be considered as unauthorized and shall not be paid for under the provisions of the Contract. Work so done may be ordered removed or replaced at the Contractor's expense.

Upon failure of the Contractor to comply with any order of the Engineer under the provisions of this Section, the Engineer shall have authority to cause unacceptable Work to be remedied or removed and replaced and unauthorized Work to be removed, and to deduct the costs from any monies due or to become due to the Contractor pursuant to 109.14.

105.13 Load Restrictions. The Contractor shall comply with all legal load restrictions in the hauling of materials on public roads. A special permit shall not relieve the Contractor from its sole liability for damage that may result from the moving of equipment or materials, whether caused by the Contractor's or its subcontractors' equipment.

The operation of equipment of such weight or so loaded as to cause damage to structures, utilities, or the roadway or to any other type of construction shall not be permitted. Hauling of materials over the base course or surface course of a roadway under construction shall be limited as directed by the Engineer. No loads will be permitted on a concrete pavement, base or structure before the expiration of the curing period. In no case shall legal load limits be exceeded unless permitted in writing by the Engineer. The Contractor shall be responsible for all damage done by its equipment or its subcontractors' equipment and the Contractor shall defend, indemnify and hold harmless the City as provided in 107.24 relating to any damage done by its equipment or its subcontractors' equipment.

105.14 Maintenance during Construction. The Contractor shall maintain the Work in a presentable and safe condition during construction and until the Project is accepted. Maintenance of the Work shall include continuous and effective work prosecuted day by day, with adequate equipment and forces so that the roadway, conduits or structures are kept in satisfactory condition at all times. The Contractor shall be responsible for damage done by its equipment or its subcontractors' or suppliers' equipment and the Contractor shall defend, indemnify, and hold harmless the City as provided in 107.24 relating to damage caused by the Contractor's or its subcontractors' or suppliers' equipment.

The Contractor shall maintain the previous courses or subgrade during all construction operations, when placing a course upon other courses of embankment, base, subgrade, concrete or asphalt pavement, or other similar items previously constructed. This maintenance includes, but is not limited to, draining, re-compacting, re-grading, or if destroyed, the removal of Work previously accepted by the City.

Maintain Stormwater Best Management Practice (BMP) features. Prevent sediment laden surface water from coming in contact with BMP features during construction.

Temporary restoration of street surfaces shall be made on installation of underground lines and structures, surplus excavation shall be removed, and the street graded and put in a safe and passable condition. Settlements occurring in or adjacent to trenches shall be immediately refilled to the proper grade. Failure on the part of the Contractor to restore the street surface to the satisfaction of the Engineer may be considered a cause sufficient for suspending the applicable work until such restoration. In the event the Engineer orders the Work suspended for conditions under this Section, the expense and time, whether direct or indirect, for such suspension shall be borne solely by the Contractor and shall not be considered a suspension of work under 104.02.C.

The Contractor shall repair, restore and clean streets and other public facilities outside the Construction Limits that are affected by its operations, including hauling and delivery of materials.

If the Contract does not contain an Item 616 – Dust Control, all costs of maintenance work and dust control during construction and before the Project is accepted shall be included in the Contract Sum.

All costs of maintenance work during construction and before the Project is accepted shall be included in the Contract Sum and the Contractor shall not be paid an additional amount for such work.

105.15 Failure to Maintain Roadway or Structures, Traffic Control Facilities and Other Appurtenances. If the Contractor, at any time, fails to comply with the provisions of 105.14, the Engineer will immediately notify the Contractor of such non-compliance. If the Contractor fails to remedy unsatisfactory maintenance within twenty four hours after receipt of such notice, the Engineer may immediately proceed to maintain the Project site and the entire cost of this maintenance will be deducted from monies due or to become due the Contractor on the Contract pursuant to 109.14.

105.16 Borrow and Waste Areas. Before any borrow or waste disposal operations are to begin, the Contractor shall submit its plan for operation, control of drainage water, cleanup, shaping, and restoration of the disturbed areas and obtain the Engineer's written approval. The plan of operations shall include the following:

A. Control of drainage water.

B. Cleanup, shaping, and restoration of disturbed areas.

C. Disposal of regulated materials.

D. Avoidance of regulated areas.

E. Excavation and filling of waste and borrow areas.

F. Saving of topsoil.

G. Temporary Sediment and Erosion Control BMPs required for compliance under the Clean Water Act, Ohio Water Pollution Control Act, (OWPCA) (ORC Chapter 6111), any applicable individual and/or general National Pollutant Discharge Elimination System (NPDES) permit, any applicable provisions of the City of Columbus Stormwater Drainage Manual, and the provisions of any applicable Stormwater Pollution Prevention Plan.

When it becomes necessary to locate such areas in or near streams, special precautions shall be taken.

The stability of borrow and waste areas and any damage to surrounding property resulting from movement of the area shall be the sole responsibility of the Contractor. Perform all engineering necessary to ensure long term stability of all side slopes and foundations of all borrow and waste areas. If requested by the Engineer, furnish a certification by a Registered Engineer attesting to the stability of all borrow and waste areas. The Contractor shall defend, indemnify and hold harmless the City as provided in 107.24 for all damage resulting from the instability of borrow and waste areas, the removal of borrow materials, the placement of waste materials, or the hauling of material to and from these areas. Repairs to approved haul roads shall be made in accordance with 105.13.

Restoration of all borrow or waste areas shall include cleanup, shaping, replacement of topsoil and establishment of vegetation cover by seeding and mulching in accordance with the requirements of Item 659 at no additional cost to the City. The restored area shall be well drained unless approval is given by the Engineer to convert a pit area into a pond or lake, in which case restoration measures shall be confined to the disturbed areas above the anticipated normal water level.

If burning is permitted under the OAC-3745-19 and ORC 1503.18, submit a copy of the Ohio EPA permit and the Ohio DNR permit to the Engineer and copies of all information used to obtain the permit.

Prior to the disposal of waste materials, submit to the City an executed copy of the contract or permission statement from the property owner. The contract or permission statement must indicate that the waste materials are not the property of the City. Further, it must expressly state that the City is not a party to the contract or permission statement and that the Contractor and property owner will defend, indemnify and hold harmless the City as provided in 107.24 relating to their contract or permission statement. The disposal of waste materials shall be in compliance with the hazardous and solid waste laws and regulations of the state of Ohio, Franklin County, Ohio, and the City of Columbus.

The cost of work described herein necessary to secure these results shall be included in the Contract Price bid for these items to which they apply. The cost of work described herein is incidental to the Contract, unless included under another item of work.

105.17 Use of Fire Hydrants. In accordance with City Code and the Division of Water rules and regulations, the Contractor shall obtain the proper hydrant permit(s), and pay any applicable fees, for the use of hydrant(s) deemed necessary for work performed under this Contract. Permit(s) must be obtained from the jurisdiction owning and maintaining the hydrant (for areas outside Columbus corporation limit) and from the Division of Water Permit Office (for areas inside Columbus corporation limit). The Contractor shall adhere to all rules and regulations governing said permit and must have the original permit on site anytime in which the hydrant is in use.

Cost of the permit and application fees shall be included in the Contract Sum.

105.18 Moving of Equipment. Non-rubber tired vehicles or equipment shall not be moved on City streets. Permits to do so must be obtained from the Department of Public Service.

105.19 Construction and Demolition Debris, Vegetative Debris, and Clean Soil.

A. Construction and Demolition Debris. The Contractor shall manage Construction and Demolition Debris generated in carrying out the Work in compliance with the requirements of ORC Chapter 3714, OAC Chapter 3745-400, the regulations of the Franklin County Board of Health, and the City of Columbus Health Code. The Contractor shall dispose of Construction and Demolition Debris at a licensed Construction and Demolition Debris facility or as otherwise authorized in OAC 3745-400-04.

The Contractor shall maintain records establishing compliance with ORC Chapter 3714, OAC Chapter 3745-400, the regulations of the Franklin County Board of Health, and the City of Columbus Health Code in the management and disposal of Construction and Demolition Debris generated in carrying out the Work.

B. Clean Hard Fill. The Contractor shall manage and/or dispose of Clean Hard Fill generated in carrying out the Work in compliance with the requirements of OAC 3745-400-05 and as follows:

1. Recycle the Clean Hard Fill into a usable construction material if allowed by the Contract Documents;
2. Dispose of the Clean Hard Fill in licensed construction and demolition debris or other waste facilities;
3. Use the Clean Hard Fill in legitimate fill operations for construction purposes or to bring the site up to a consistent grade, on the site of generation if allowed by the Contract Documents; or
4. Use the Clean Hard Fill in legitimate fill operations for construction purposes or to bring the site up to a consistent grade, on a site other than the site of generation, if allowed by the Contract Documents provided that:

    a. The Contractor shall provide a written "Notice of Intent to Fill" to each licensing authority where the clean hard fill is to be placed. The notification shall be received by each local licensing authority with sites to be filled, at least seven days prior to filling as required by division (F) of Section 3714.13 of the Revised Code. The Contractor shall provide a new Notice of Intent to Fill if there are any changes in the information required for notification under OAC 3745-400-05.

    The Notice of Intent to Fill shall state:

    i. The nature of the fill material, the site(s) to be filled;

ii. When filling will begin and end; and

iii. The telephone number of the Contractor.

Clean Hard Fill generated in Franklin County, Ohio and that is hauled off the site at which the fill was generated, must be hauled by a waste hauler registered with the Franklin County Board of Health in a vehicle permitted by the Franklin County Board of Health.

The Contractor shall maintain records establishing compliance with OAC 3745-400-05, the regulations of the Franklin County Board of Health, and the City of Columbus Health Code in the management and disposal of Clean Hard Fill generated in carrying out the Work.

C. Vegetative Debris. Trees, brush, stumps, tree trimmings, branches, weeds, leaves, grass, shrubbery, yard trimmings, crop residue, and other vegetative debris generated in the clearing and grubbing of a construction site in the course of performing the work shall be managed and disposed of as follows:

1. If specifically allowed by the Contract Documents, vegetative debris generated in the clearing and grubbing of a construction site in the course of performing the Work may be used as fill material at the site on which such debris was generated, either alone or in conjunction with clean soil, sand, gravel, or other clean aggregates, in legitimate fill operations for construction purposes or to bring the site up to a consistent grade;
2. Vegetative debris not used in legitimate fill operations at the site of generation shall be disposed of at a licensed yard waste composting facility; or
3. Vegetative debris not used in legitimate fill operation at the site of generation shall be disposed of at a licensed solid waste disposal facility if a yard waste compost facility has refused to accept the vegetative debris and the Contractor obtains a Refusal of Acceptance form.

The Contractor shall maintain records establishing compliance with OAC Chapter 3745-27 in the management and disposal of vegetative debris generated in carrying out the Work.

D. Clean Soil. Clean Soil generated in the City of Columbus or Franklin County, Ohio shall be managed and disposed of in compliance with the provisions of the City of Columbus Health Code and the regulations of the Franklin County Board of Health and as follows:

1. If allowed by the Contract Documents, use the Clean Soil in legitimate fill operations for construction purposes or to bring the site up to a consistent grade, on the site of generation if allowed by the Contract Documents; or
2. If allowed by the Contract Documents, use the Clean Soil in legitimate fill operations for construction purposes or to bring the site up to a consistent grade, on a site other than the site of generation, if allowed by the Contract Document; or
3. Dispose of the Clean Soil at a registered clean fill disposal site.

Clean Soil generated in Franklin County, Ohio and that is hauled off the site at which the fill was generated must be hauled by a waste hauler registered with the Franklin County Board of Health in a vehicle permitted by the Franklin County Board of Health.

The Contractor shall maintain records establishing compliance with OAC Chapter 3745-27, the regulations of the Franklin County Board of Health, and the City of Columbus Health Code in the management and disposal of clean soil generated in carrying out the Work.

If the Project contains garbage or solid and hazardous waste, the Contract Documents will detail the removal of these items in compliance with Ohio's solid and hazardous waste laws and regulations, the regulations of the Franklin County Board of Health, and the City of Columbus Health Code.

When wasting PCC, mix the PCC with at least 30 percent natural soil to construct an inner core in the waste area. Cover this inner core with 3 feet of natural soil on the top and 8 feet on the side slopes. Place and compact the material according to 203.06.D to prevent future settlement and sliding.

When the wasting of clean hard fill is allowed, comply with all the requirements of this Section and 105.16.

ITEM 106 CONTROL OF MATERIAL

106.01 Source of Supply and Quality Requirements
106.02 Samples, Tests, Cited Specifications
106.03 Small Quantities and Materials for Temporary Application
106.04 Plant Sampling and Testing Plan
106.05 Storage of Materials
106.06 Handling of Materials
106.07 Unacceptable Materials
106.08 City-Furnished Materials

106.01 Source of Supply and Quality Requirements. The materials used for the Work shall meet all requirements of the Contract. In order to expedite the inspection and testing of materials, the Contractor shall notify the Engineer of the proposed sources of materials prior to delivery. At the option of the Engineer, materials may be inspected at the source of supply before delivery is started. If it is determined by the Engineer that sources of supply for previously approved materials do not produce specified products, the Contractor shall furnish materials from other sources without adjustment to the Contract Sum or Time.

The Contractor shall furnish or cause to be furnished to the Engineer, delivery tickets or documents for all materials to be incorporated in the Work. Tickets or documents shall describe in detail the type, size, specification or data, fully denoting the materials being delivered.

106.02 Samples, Tests, Cited Specifications. All materials will be inspected and tested, and the compliance will be determined by the Engineer before incorporation into the Work. The City may sample and test materials or require certifications. Unless otherwise designated, tests in accordance with AASHTO, ASTM or other methods on file at the Laboratory will be made by and at the expense of the City. Samples will be taken by a qualified representative of the City.

All materials being used are subject to inspection, test or rejection at any time prior to incorporation into the Work. Copies of all tests will be furnished to the Contractor's representative. The Contractor, in all cases, shall furnish the required samples and specified material certifications at no expense to the City.

Transports and distributors hauling bituminous material shall be equipped with an approved submerged bituminous material sampling device.

If, in the judgment of the Engineer, the quantity used of any one material is so inconsequential as to not warrant testing in accordance with the minimum requirements for sampling materials in Section 700, verification of the quality of the material may be covered by a Field Inspection Report of Materials, prepared by the Engineer.

106.03 Small Quantities and Materials for Temporary Application. The Engineer may accept small quantities and materials for temporary application that are not intended for permanent incorporation into the Work. The Engineer may accept these small quantities and materials for temporary application in either of the following cases:

A. Where similar materials from the same source have recently been approved.

B. Where the materials, in the judgment of the Engineer, will serve the intended purpose.

106.04 Plant Sampling and Testing Plan. The Engineer or an authorized representative may undertake the inspection of materials at the source.

In the event plant sampling and testing is undertaken, the Contractor and its material provider shall meet the following conditions:

A. The Engineer shall have the cooperation and assistance of the Contractor and the producer with whom the Contractor has contracted for materials.

B. The Engineer or an authorized representative shall have full entry at all times to such parts of the plant as may concern the manufacture or production of the materials being furnished.

C. If required by the Engineer, the Contractor shall arrange for an approved building for the use of the Inspector. The building should be located conveniently near the plant and independent of any building used by the material producer.

D. Adequate safety measures at the plant shall be provided and maintained.

The City reserves the right to retest all materials that have been tested and accepted at the source of supply before their incorporation into the Work. After the approved materials have been delivered to the site, the City may reject all materials that, when retested, do not meet the requirements of the Contract Documents or those established for the specific project.

106.05 Storage of Materials. Materials shall be so stored as to assure the preservation of their quality and fitness for the Work. Stored materials, even though approved before storage, may again be inspected prior to their use in the Work. Stored materials shall be located so as to facilitate their prompt inspection. Approved portions of the right-of-way may be used for storage purposes and for the placing of the Contractor's plant and equipment, but any additional space required therefore must be provided by the Contractor at no expense to the City. Private property shall not be used for storage purposes without written permission of the owner or lessee, and if requested by the Engineer copies of such written permission shall be furnished. All storage sites shall be restored to their original condition by the Contractor at no expense to the City and the Contractor shall defend, indemnify and hold harmless the City as provided in 107.24 relating to their contract or permission statement.

106.06 Handling of Materials. All materials shall be handled in such manner as to preserve their quality and fitness for the Work. Aggregate shall be transported from the storage site to the project in tight vehicles so constructed as to prevent loss or segregation of materials after loading and measuring in order that there may be no inconsistencies in the quantities of materials intended for incorporation in the Work as loaded, and the quantities as actually received at the place of operations.

106.07 Unacceptable Materials. All materials not conforming to the requirements of the Contract Documents at the time they are used shall be considered unacceptable and shall be removed immediately from the site of the Work unless otherwise instructed by the Engineer. Unacceptable materials allowed to remain in place shall be addressed according to 105.03. No previously identified unacceptable materials, the defects of which have been corrected, shall be used until approval has been given. Upon failure on the part of the Contractor to comply immediately with any order of the Engineer made under the provisions of this Section, the Engineer shall have authority to remove and replace defective materials and to deduct the cost of removal and replacement from any monies due or to become due to the Contractor pursuant to 109.14.

106.08 City-Furnished Materials. The Contractor shall furnish all materials required to complete the Work, except when otherwise provided in the Contract Documents.

Materials furnished by the City will be delivered or made available to the Contractor at the points specified in the Contract Documents.

The cost of handling and placing all materials after they are delivered to the Contractor shall be considered as included in the Contract Price for the item in connection with which they are used.

The Contractor shall be responsible for all delivered materials, and deductions will be made from any monies due the Contractor to make good any shortages and deficiencies, from any cause whatsoever, and for any damage which may occur after such delivery, and for any demurrage charges.

ITEM 107 LEGAL RELATIONS AND RESPONSIBILITY TO PUBLIC

107.01 Laws to be Observed
107.02 Permits, Licenses and Taxes
107.03 Patented Devices, Materials and Processes
107.04 Restoration of Surfaces Opened by Permit
107.05 Government-Aid Provisions
107.06 Sanitary Provisions
107.07 Public Convenience and Safety
107.08 Barricades and Warning Signs
107.09 Maintenance of Traffic
107.10 Use of Explosives
107.11 Protection and Restoration of Property
107.12 Contractor's Use of the Project Right-of-Way or Other City-Owned Property
107.13 Responsibility for Damage Claims
107.14 Motorist Damage Claims
107.15 Opening Sections of Project to Traffic
107.16 Contractor's Responsibility for Work
107.17 Contractor's Responsibility for Utility Property and Services
107.18 Furnishing Right-of-Way
107.19 Personal Liability of Public Officials
107.20 No Waiver of Legal Rights
107.21 OSHA
107.22 Litigation
107.23 Environmental and Natural Resources Protection
107.24 Indemnification

107.01 Laws to be Observed. The Contractor shall keep fully informed of all Federal, State and local laws, ordinances, codes and regulations and all orders and decrees of authorities having any jurisdiction or authority, which in any manner affect those engaged or employed on the Work, or which in any way affect the conduct of the Work. The Contractor shall at all times observe and comply with all such laws, ordinances, codes, regulations, orders, and decrees; and shall protect and defend, indemnify and hold harmless the City as provided in 107.24 relating to violation of any such law, ordinance, code, regulation, order, or decree, whether by the Contractor or its employees or agents, or the Contractor's subcontractors or suppliers.

The Contractor, under Title VI of the Civil Rights Act and related statutes, agrees that in the hiring of employees for the performance of work under this Contract or any subcontract hereunder, no Contractor or subcontractor, nor any person acting on behalf of such Contractor or subcontractor, shall, by reason of race, sex, sexual orientation, gender identity or expression, color, religion, ancestry, national origin, age, disability, family status, or military status discriminate against any citizen of the United States in the employment of labor or workers, who is qualified and available to perform the work to which the employment relates. No Contractor, subcontractor, nor any of their employees or agents shall, in any manner, discriminate against or intimidate any employee hired for the performance of work under this Contract on account of race, sex, sexual orientation, gender identity or expression, color, religion, ancestry, national origin, age, disability, family status, or military status.

107.02 Permits, Licenses and Taxes. The Contractor shall procure all permits and licenses, pay all charges, fees, and taxes, and give all notices necessary and incidental to the due and lawful prosecution of the Work.

Prior to the closure of or working in or on any portion of a street, the Contractor shall obtain a permit from the Department of Public Service.

The Contractor shall include and pay all state and local sales, consumer and use taxes. Materials purchased for incorporation into the work will be exempt from state and local sales tax. A sales tax exemption certificate will be issued by the City at the request of the Contractor.

A. Licensed Water Contractor Requirement. It shall be unlawful for any person to perform any work on City of Columbus water line systems without first securing license to engage in such work, as indicated in Columbus City Code Section 1103.06. This work includes any attachments, additions, alterations, or rehabilitation of any city service pipe or appurtenances (including water service lines and taps). This requirement may be met by utilization of a subcontractor who holds a City of Columbus Water Contractor License or a Combined Water/Sewer Contractor License to perform this work. Utilization of a subcontractor must meet the licensing requirements of City of Columbus Building Code, in particular Section 4114.119 and 4114.529. The License must be in effect the day of the bid opening and at the time of Work.

B. Licensed Sewer Tapper Requirement. It shall be unlawful for any person to engage in the business of sewer tapping and sewer building, or to open or tap any sewer in any street, alley or any public or private place or rehabilitation of any sewer or appurtenances (including manholes, inlets, and service laterals) in the City of Columbus without first securing license to engage in such business, as indicated in Columbus City Code Section 1131.01. Utilization of subcontractor must meet the licensing requirements of City of Columbus Building Code, in particular Section 4114.119 and 4114.529. The License must be in effect the day of the bid opening and at the time of Work.

107.03 Patented Devices, Materials and Processes. If the Contractor employs any design, device, material, or process covered by letters of patent or copyright, suitable legal agreement(s) with the patentee or owner shall be provided for such use. The Contractor shall defend, indemnify and hold harmless the City, as well as any affected third party or political subdivision, as provided in 107.24 relating to any infringement by reason of the use of any such patented design, device, material or process or any trademark or copyright.

The Contractor must obtain the approval of the City to substitute a patented material or process specified in the Contract Documents.

In the case of patented pavements and wearing courses, where royalties, licensing and proprietary service charges exacted or to be exacted by the patentees are published and certified agreements are filed with the City, guaranteeing to prospective Bidders free unrestricted use of all such proprietary rights and trademarked goods upon payment of such published charges, such patented payments may be specifically designated in the Proposal and competition secured upon the item exclusive of the patent or proprietary charges.

107.04 Restoration of Surfaces Opened by Permit. The right to construct or reconstruct any utility service in the roadway, street, or right-of-way or to grant permits for same, at any time, is hereby expressly reserved by the Director, or the owner of said roadway, street or right-of-way.

Any individual, firm, or corporation wishing to make an opening in the street must secure a permit. The Contractor shall allow parties bearing such permits, and only those parties, to make openings in the roadway.

When ordered by the Engineer, the Contractor shall make in an acceptable manner all necessary repairs due to such openings and such necessary work will be paid for as provided in the Specifications, and the repair work shall conform to the Contract Documents.

107.05 Government-Aid Provisions. When the United States Government or the State of Ohio Government pays for all or any portion of the Project's cost, the federal or State laws and the rules and regulations made pursuant to such laws must be observed and the Work is subject to the inspection of the appropriate Federal and/or State agency.

Such inspections shall not make the Federal or State Government a party to this Contract and such inspections will in no way interfere with the rights of the Contractor or the City under the Contract.

107.06 Sanitary Provisions. The Contractor shall provide and maintain in a neat, sanitary condition such accommodations for the use of its employees and City representatives as may be necessary to comply with the requirements of the State and local Board of Health, or of other authorities having jurisdiction.

107.07 Public Convenience and Safety. The Contractor shall, at all times, conduct the Work so as to ensure the least possible obstruction to traffic. The safety and convenience of the general public and the residents along the street and the protection of persons and property shall be provided for by the Contractor as specified under 104.04.

The Contractor shall provide and maintain safeguards, safety devices and protective equipment and take any other needed actions as may be necessary to protect the public and property in connection with the work. Do not close streets unless specifically allowed by the Contract.

The presence of barricades or lights provided and maintained by any party other than the Contractor shall not relieve the Contractor of this responsibility.

107.08 Barricades and Warning Signs. Temporary traffic control devices and facilities shall be furnished, erected, maintained and paid for in accordance with the provisions of Item 614, Maintaining Traffic. All traffic control devices shall conform to Part 6 of the OMUTCD for Streets and Highways as amended, as required under Section 4511.09 of the Ohio Revised Code. The provisions of this item and this Section shall not in any way relieve the Contractor of any of its legal responsibilities or liabilities for the safety of the public.

107.09 Maintenance of Traffic. All work shall be performed in accordance with Item 614 - Maintaining Traffic.

To avoid interruption of bus and coach operations, the Contractor shall give sufficient advance notice to the company or companies concerned to permit rerouting of lines, if necessary.

When material is piled in the gutters, suitable drains of sufficient size to carry all the storm water flowing in the gutters shall first be laid. Where the drainage from cross streets or alleys is interfered with or cut off by reason of the nature of the work, suitable crossings shall be provided for pedestrians. No material shall be piled within 20 feet of any fire hydrant.

The Contractor shall notify the Columbus Fire and Police Divisions and "Paving the Way" whenever a street or section of street is about to be closed to traffic and also when it is to be opened.

107.10 Use of Explosives. When and if it is necessary for the prosecution of the Work to resort to blasting with explosives, the Contractor shall use the highest degree of care and adequate protective measures so as not to endanger life, completed portions of the Work, and all other property, both public and private. Before conducting any blasting operations, the Contractor shall furnish the Engineer, in writing, a schedule of intended blasting operations and it shall give the Engineer prior written notification of any changes in such schedule.

The use, handling, storage and transportation of explosives shall conform and be in accordance with the applicable requirements and/or provisions of:

1. the latest revision of "State of Ohio Administrative Code Chapter 4121:1-3," issued by the Department of Industrial Relations and the Industrial Commission of the State of Ohio;
2. the Ohio Explosive Laws, Section 3743.01 - 3743.26 of the ORC and amendments thereto;
3. local regulations; and
4. as specified herein.

The Contractor shall secure a written permit from the Department of Public Safety, Division of Fire, of the City of Columbus before any blasting work is begun.

All shot firing shall be done by Institute of Makers of Explosives (IME) approved electrical or non-electric blasting systems which allows the blaster to control the exact moment in which firing of the shot will occur. The Contractor shall make suitable provisions to prevent the scattering of broken rock, earth, stones or other material during blasting operations.

107.11 Protection and Restoration of Property. The Contractor is responsible for the preservation of all property impacted by the Contractor's operations.

The Contractor is responsible for all damage or injury to property, during the prosecution of the Work, resulting from any act, omission, neglect, defective work or materials, or misconduct in the manner or method of executing the Work. The Contractor shall remain responsible for all damage and injury to property until the Project is accepted under 109.11. The Contractor shall defend, indemnify and hold harmless the City as provided in 107.24 relating to any damage or injury to property. If the Contractor causes any direct or indirect damage or injury to public or private property by any act, omission, neglect, or misconduct in the execution or the non-execution of the Work, then it must restore, at its own expense, the property to a condition similar or equal to that existing before the damage or injury.

If mailboxes, road, or street name signs and supports interfere with the Work, then remove and erect them in a temporary location during construction in a manner satisfactory to and as directed by the Engineer. After completion of the Work and before final acceptance of the Project, erect the mailboxes, road, or street name signs and supports in their permanent locations according to the plans unless otherwise directed by the Engineer. Consider the cost of this Work as incidental to the affected items.

Cooperate with the Engineer in protecting and preserving survey monuments that are affected by the Work as required by ORC 5519.05. At the beginning of the Work, verify the position of all survey monuments in the area to be improved, according to 623. If survey monuments not shown in the Contract Documents are unexpectedly encountered, then protect, reference, and preserve them in the same manner as survey monuments that are shown in the Contract Documents.

Do not create staging areas, store materials and equipment, or borrow or waste materials in areas labeled as an environmental resources area in the Contract Documents. All properties to be utilized by the Contractor outside the project Work Limits must be cleared for all environmental resource impacts prior to the beginning of work. Environmental resources include but may not be limited to:

1. Cultural Resources
    a. Buildings, structures, objects, and sites eligible for or listed on the National Register of Historic Places
    b. Historic or prehistoric human remains, cemeteries, and/or burial sites (pursuant with ORC 2909.05 and 2927.11)
2. Ecological Resources
    a. Wetlands
    b. Streams
    c. Wooded areas with trees to be removed in excess of 8 inches diameter at breast height
3. Public Lands
    a. Lands meeting the criteria of 49 U.S.C. 303, 23 CFR 771.I35: 4(f).
    b. Lands meeting the criteria of 16 U.S.C. 4601-4, 36 CFR59.1: 6(f).
4. FEMA Mapped 100 year Floodplains
5. Hazardous Waste Areas

Except for locations utilized specifically for:

1. Parking of equipment between workdays for maintenance type projects:
2. Reuse of Clean Hard Fill as described in CA-EW-20 (ODOT Beneficial Reuse Form). Prior to transferring Clean Hard Fill from the project, fully execute form CA-EW-20 and provide appropriate documentation to the Engineer as described for each reuse option.

All areas proposed to be utilized by the Contractor outside the Construction Limits and not described above shall be reviewed by the City and/or environmental contractor(s) that are prequalified by the City for each environmental resource. Exception (1.) noted above only applies to projects with "maintenance" in the project description. Have the consultant(s) certify that the proposed site to be utilized for the Contractor will not impact:

1. Cultural Resources
2. Ecological Resources
3. Public Lands
4. FEMA Mapped 100 year Floodplains
5. Hazardous Waste Areas

Provide all documentation and the consultant certification to the Engineer.

Should the areas proposed for use by the Contractor outside the project right-of-way limits contain environmental resources, the Contractor is responsible to the City for all environmental clearances and permits prior to the beginning of Work.

107.12 Contractor's Use of the Project Right-of-Way or Other City-Owned Property.

A. Disposal of Waste Material and Construction Debris and Excavation of Borrow on the Project Right-of-Way or on Other City-Owned Property. Dispose of waste material according to 105.16 and dispose of construction debris according to 105.19. In addition to the rights granted in 104.05, the Contractor's use of the Project Right-of-Way or other City-owned property for the disposal of waste material and construction debris and excavation of borrow material is restricted as follows:

1. If the Contract Documents identify locations for the disposal of waste material and construction debris or excavation of borrow material within the Project Right-of-Way or on other City-owned property, then only perform these operations in these designated locations.
2. If the Contract Documents do not identify locations for the disposal of waste material and construction debris or excavation of borrow material within the Project Right-of-Way or on other City-owned property, then do not bid assuming that the City will make such locations available.

If the Contractor's request to use locations within the Project Right-of-Way or on other City-owned property is approved by the Engineer, then the City may allow the Contractor to dispose of waste material and construction debris or excavate borrow material for a fee of $0.50 per cubic yard.

B. Equipment Storage and Staging. The Contractor shall not bid in anticipation of using any properties within the Project Right-of-Way or any City-owned property that is outside the Project Right-of-Way for equipment storage or staging. Subject to the approval of the Engineer, the Contractor may be permitted to use, fee-free, any portion of the Project within the Project Right-of-Way for staging, equipment storage, or an office site, provided such usages do not interfere with the Work and are not prohibited by the Contract Documents.

C. Equipment Removal and Site Restoration. Remove all Contractor equipment and completely restore all utilized sites used as required by 104.07 before Final Acceptance as provided in 109.11.

107.13 Responsibility for Damage Claims. The Contractor shall defend, indemnify and hold harmless the City, as well as any participating railroad or railway company, as provided in 107.24 relating to any injuries or damages sustained by any person or property in consequence of any neglect in safeguarding the work or through the use of unacceptable materials in the construction of the Project or on account of any act or omission, by the Contractor, its agents, its subcontractors, or its suppliers.

107.14 Motorist Damage Claims. The resolution of motorist damage claims shall comply with the provisions of Sections 335.01 and 335.012 of City Code.

107.15 Opening Sections of Project to Traffic.

A. When Ordered by the Engineer. Upon written notice from the Engineer directing that the highway, street, bridge, or culvert, or any part thereof be opened for travel, the Contractor shall put the highway, street, bridge or culvert or such portions thereof as the Engineer may direct in such condition for travel as the Engineer may direct, and shall remove all barriers and obstructions. The Engineer's direction to open for travel shall not constitute Acceptance of the Work in whole or in part. However, the Contractor shall not be responsible for damage by such traffic to completed or partially completed portions of the Work. Additional costs and time to the Contractor by such action shall be reimbursed in accordance with 104.02.F and 108.06.D, as applicable.

B. When Progress is Unsatisfactory or Work is Suspended by the Contractor. When a portion of a roadway or a structure is completed and the progress schedule for the Work has not been met or the Contractor suspends work for over fourteen days during the normal construction season, the Engineer on written notice to the Contractor may order the road or structure to be opened for travel and the Contractor shall place the highway, street, structure, or portions thereof in such condition for travel as the Engineer may order and shall remove all barriers and obstructions at no cost to the City.

107.16 Contractor's Responsibility for Work. Until Final Acceptance of the Project by the Engineer, the Contractor shall have the charge and care thereof and shall take every precaution against injury or damage to any part thereof by the action of the elements, from vandalism, from vehicular accidents, or from any other cause, whether arising from the execution or from the non-execution of the Work. The Contractor shall rebuild, repair, restore and make good all injuries or damages to any portion of the Work occasioned by any of the above causes before Final Acceptance. The Contractor shall bear the expense of the repairs except when damage to the Work was due to unforeseeable causes beyond the control of and without the fault or negligence of the Contractor. Unforeseeable causes include but are not restricted to; (a) earthquake, floods, tornados, high winds, lightning or other catastrophes proclaimed a disaster or emergency, (b) strikes, (c) civil disturbances, or (d) governmental acts.

In case of suspension of work by the Contractor, or under the provisions of 105.01.B, the Contractor shall be responsible for the Work and shall take such precautions as may be necessary to prevent damage to the Work, provide for adequate drainage, erect any necessary temporary structures, temporary pavements, signs, or other facilities, and providing required maintenance of traffic and public and private access to property, all at the Contractor's expense. During such period of suspension of work, the Contractor shall properly and continuously maintain in an acceptable growing condition all living material in newly established plantings, seeding, and sodding furnished under the Contract, and shall take adequate precautions to protect new tree growth and other important vegetative growth against injury.

107.17 Contractor's Responsibility for Utility Property and Services. At points where the Contractor's operations are adjacent to properties of railway, telephone, cable, fiber optics, and power companies, or are adjacent to private wells, private wastewater disposal facilities, private

stormwater conveyance systems and other utilities or property, damage to which might result in considerable expense, loss, or inconvenience, work shall not be commenced until all arrangements necessary for the protection thereof have been made.

The Contractor shall cooperate with the owners of any underground or overhead utility lines in their protection and in removal and rearrangement operations in order that these operations may progress in a reasonable manner, that duplication of rearrangement work may be reduced to a minimum, and that services rendered by those parties will not be unnecessarily interrupted.

In the event of interruption to underground or overhead utility services, water lines, private water wells, private wastewater disposal facilities or utility services as a result of accidental breakage or as a result of being exposed or unsupported, the Contractor shall immediately notify the occupants of nearby premises and the proper authority or operator of the utility facility of the disruption and shall cooperate with the said authority in the restoration of service. If water or sewer service is interrupted, repair work shall be continuous until the service is restored by a licensed Contractor. No work shall be undertaken around fire hydrants until provisions for continued service have been approved by the local fire authority.

107.18 Furnishing Right-of-Way. The City will be responsible for the securing of all necessary rights-of-entries in advance of construction. The Bid Documents will indicate any exceptions. The City will notify all prospective Bidders in writing before the date scheduled for receipt of Bids regarding the specific dates certain parcels will be made available to the Contractor.

107.19 Personal Liability of Public Officials. In carrying out any of the provisions of these specifications, or in exercising any power or authority granted to them by or within the scope of the Contract, there shall be no liability of the Director or other City-authorized representatives, either personally or as officials of the City, it being understood that in all such matters they act solely as agents and representatives of the City.

107.20 No Waiver of Legal Rights. No action or inaction by the City, including but not limited to, the inspection by the Engineer, nor by any inspector or duly authorized City representatives, nor any order, measurements, or certificate by the Director, or said representatives, nor any order by the Director for the payments of money, nor any payment for, nor acceptance of any Work by the Engineer, nor any extension of time, nor any possession taken by the City or its duly authorized representatives, shall operate as a waiver of any provision of this Contract, or of any power herein reserved to the City, or any right to damages herein provided, or any other rights or remedies that the City may have under the Contract, at law or otherwise; nor shall any waiver of any breach of the Contract be held to be a waiver of any other subsequent breach.

107.21 OSHA. All Contractors shall comply with the provisions of the Occupation Safety and Health Act of 1972 and all amendments thereto.

107.22 Litigation. All lawsuits involving claims, counterclaims, disputes and other matters in question between the City, its agents and employees, and the Contractor arising out of or relating to this Contract or its breach shall be brought in and decided by a court of competent jurisdiction within the County of Franklin, State of Ohio, and the law of Ohio shall govern without reference to its conflict of laws rules, if applicable.

107.23 Environmental and Natural Resources Protection. Comply with all Federal, State, and local laws and regulations controlling protection of the environment and natural resources. Avoid polluting streams, lakes, ponds, reservoirs and other bodies of water with fuels, oils, bitumens, chemicals, sediments, or other harmful materials, and avoid polluting the atmosphere with particulate and gaseous matter. Adopt sustainability best management practices, including but not limited to, clean and efficient energy use, the use of recycled materials if allowed by the Contract Documents, and waste reduction and recycling.

A. Water Pollution Control. The Contractor shall comply with all Federal, State and local water pollution control laws and regulations, permits, plans, and policies, including but not limited to:

1. The Clean Water Act and the regulations promulgated thereunder;
2. Ohio Revised Code Chapter 6111 and the regulations promulgated thereunder;
3. City of Columbus Stormwater Drainage Manual;
4. Individual NPDES Permits issued for City of Columbus Facilities;
5. Ohio General Permit to Discharge Stormwater associated with Industrial activity, if applicable;
6. Ohio General Permit for filling Category 1 and Category 2 Isolated Wetlands;
7. Ohio EPA General Permit for Storm Water Discharges Associated with Construction Activity;
8. Ohio EPA General Permit for Storm Water Discharges Associated with Construction Activity in the Big Darby Watershed;
9. Ohio EPA General Permit for Storm Water Discharges Associated with Construction Activity in the Olentangy River Watershed;
10. Stormwater Pollution Prevention Plans adopted for City of Columbus facilities and/or required for the Project pursuant to the Clean Water Act;
11. Any Spill Prevention Control and Countermeasures Plan required under the Clean Water Act;
12. Columbus Erosion and Sediment Pollution Control Regulation, latest revision.

When equipment is working next to a city storm sewer inlet, stream, lake, pond, reservoir, or other body of water, spill response equipment is required in the event of a hydraulic leak. Do not stockpile fine material next to a sewer inlet, stream, lake, pond, reservoir or other body of water.

Take precautions to avoid demolition debris and discharges associated with the excavation and hauling of material from entering the stream. Remove any material that does enter a storm sewer or stream immediately.

When excavating in or adjacent to streams, separate such areas from the main stream by a dike or barrier to keep sediment from entering the stream. Take care during the construction and removal of such barriers to minimize sediment entering the stream.

Accomplish control of ground water and water in excavations in a manner that prevents the degradation of the water quality of any surface water. Install wells and well points with suitable screens and filters where necessary to prevent the continuous pumping of fines. Pump sediment-laden water in a manner to prevent introduction into the city storm sewer system or degradation of streams, lakes, ponds, or other areas of water impoundment. Such prevention may involve but is not limited to the means and methods described in Item 207. Use the current version of the *Sediment and Erosion Control Handbook* to plan this work. Use the methods necessary to prevent adverse effects to surface waters as provided in OAC-3745-1-04. The cost of constructing and maintaining these measures is incidental to the Contract.

Contain, collect, characterize and legally dispose of all waste water and sludge generated during the work. Do not allow or mix any waste water with storm water. Do not discharge any waste water without the appropriate regulatory permits. Manage waste water and sludge in accordance with ORC Chapter 6111 and all other laws, regulations, permits and local ordinances relating to this waste. Waste water management is incidental to the Work unless otherwise specified in the contract.

B. Dredging, Filling, and Construction Activities in the Waters of the United States or Isolated Wetlands.

1. When the Work involves dredging, filling, and/or construction in the waters of the United States as defined by federal law, including but not limited to wetlands, and ephemeral and intermittent streams with a significant nexus to the navigable waters of the United States, the Contractor shall:

    a. Comply with the applicable United States Army Corps of Engineers (USACE) Nationwide General Permit, including any requirement to file a pre-construction notification or to obtain an individual permit;

    b. Comply with any applicable USACE Nationwide Permits Regional General Conditions, Nationwide Permits for the State of Ohio, promulgated by the USACE Huntington District Engineer;

    c. Comply with the applicable Ohio EPA Section 401 Nationwide Permits Certification General Conditions and Limitations and Special Conditions and Limitations; and

    d. Obtain an Ohio EPA Section 401 Certification for dredging, filling, and/or construction activities in the waters of the United States.

2. When the Work involves dredging, filling, and/or construction activities in an isolated wetland, the Contractor shall obtain from the Ohio EPA an isolated wetlands permit as required by ORC Sections 6111.02 through 6111.028.

C. Construction Activities or Filling in Special Flood Hazard Areas.

1. When the Work involves construction activities or filling in a Special Flood Hazard Area as defined in the City of Columbus Floodplain Management Regulations codified in Columbus City Code Chapter 1150, and these activities will occur within the Columbus city limits, the Contractor shall:

    a. Obtain a Special Flood Hazard Area Development and Use Permit from the City of Columbus, Department of Public Utilities prior to beginning the Work;

    b. Obtain prior approval for the Work from the Federal Emergency Management Agency if required under the Columbus Floodplain Management Regulations and 40 C.F.R. 60.3; and

    c. Comply with the floodplain filling mitigation requirements of the Columbus Stormwater Drainage Manual

2. When the Work involves construction activities or filling in a Special Flood Hazard Area outside the Columbus city limits, the Contractor shall obtain all necessary permits and comply with the floodplain management regulations of the jurisdiction in which these activities will occur.

D. Air Pollution Control. The Contractor shall comply with Ohio's Air Pollution Control Laws and Regulations, ORC Chapter 3704 and the regulations promulgated thereunder, including but not limited to controlling fugitive dust emissions as required under OAC 3745-17-08.

E. Solid and Hazardous Waste Management. The Contractor shall manage all solid and hazardous wastes generated in carrying out the Work in compliance with Ohio's Solid and Hazardous Waste Laws, ORC Chapter 3734 and the regulations promulgated thereunder.

F. Endangered Species. Prior to engaging in any activities that may impact the habitat of threatened or endangered species; the Contractor shall perform any environmental review required under the National Environmental Policy Act, the Endangered Species Act, or Ohio laws and regulations.

G. Historic Preservation. Where the Work may impact archaeological, historic, or cultural resources, the Contractor shall conduct any assessments, reviews, and/or studies required under the applicable provisions of the National Environmental Policy Act or other federal law and Ohio's Historic Preservation Laws and regulations, including but not limited to ORC Section 149.53 and OAC Chapter 149-1.

H. Recordkeeping. The Contractor shall maintain records establishing compliance with all applicable Federal, State and local laws and regulations, permits, plans, and policies related to environmental and natural resources protection.

107.24 Indemnification. To the fullest extent permitted by law, the Contractor shall defend, indemnify and hold harmless the City and its officers, employees, representatives, and agents (hereinafter collectively referred to as the "City") against any and all claims, actions, damages, costs, and legal liability of every name and nature that the City may sustain, incur or be required to pay (including, but not limited to, consultant and attorney's fees, disbursements, costs or other expenses) arising out of or in connection with the Work by reason of any action, inaction,

omission, or breach by the Contractor, its agent(s) or person(s) employed by the Contractor, or any of its subcontractors or suppliers, including but not limited to, (i) failure to comply with the terms and conditions of the Contract or pertinent subcontract(s), or (ii) any of the Contractor's liability under the Contract Documents.

The City may retain any amounts due or that may become due to the Contractor as may be necessary to satisfy any claim for indemnification under the Contract. The Contractor's obligation under this Section shall not be deemed waived by the failure of the City to retain in whole or any part of such monies due to the Contractor, nor shall such suit, action, damages and/or costs have to have been resolved or determined prior to the release of any monies to the Contractor under the Contract, nor shall such obligation be deemed limited or discharged by the procurement of any insurance for liability for damages imposed by law upon the Contractor, its subcontractors or suppliers, or the City.

In applying this indemnification provision, the Contractor shall be required to indemnify the City in any action brought by an employee of the Contractor, or any employee of its subcontractors or suppliers, whenever such employee is found to have been comparatively negligent, even if the Contractor and/or its subcontractors or suppliers are found not to have been negligent themselves.

The Contractor shall advise the Engineer in writing immediately upon its receipt of notice, actual or otherwise, of any (i) incident or circumstance or (ii) claim or action that could give rise to a claim covered by this indemnification provision.

ITEM 108 PROSECUTION AND PROGRESS OF WORK

108.01 Subletting of Contract
108.02 Preconstruction Conference
108.03 Prosecution and Progress
108.04 Limitation of Operations
108.05 Character of Workers, Methods, and Equipment
108.06 Determining a Time Extension to the Completion Date and Payment for Excusable Delays
108.07 Failure to Complete on Time
108.08 Unsatisfactory Progress and Default of Contractor
108.09 Certified Payroll

108.01 Subletting of Contract. A Contractor must obtain written consent from the director or designee of the Department prior to subletting, selling, transferring, assigning, or otherwise relinquishing any rights, title, or interest in the work to any subcontractor not listed in the bid submittal or contract. The director or designee must, within a reasonable time, approve or disapprove a Contractor's request. The decision shall be final. The Contractor may seek the aforementioned written consent for reasons including, but not limited to, the following:

1. After reasonable opportunity to do so, the subcontractor fails or refuses to execute a written contract for the scope of work specified in the bid and at the price specified in the bid;
2. The subcontractor becomes insolvent or the subject of an order for relief in bankruptcy;
3. The subcontractor fails or refuses to meet the requisite licensing or bonding set before bid submittal;
4. The contractor demonstrates to the contracting agency that the name of the subcontractor was listed as the result of an inadvertent clerical error;
5. The subcontractor fails or refuses to perform its subcontract after reasonable opportunity to do so; or
6. The contractor determines that additional specialty work not reasonably anticipated in the bid must be performed by subcontract.

Upon request, the contractor and its subcontractors shall promptly furnish copies of all subcontracts and supply agreements.

The Contractor must perform Work amounting to not less than 50 percent of the Contract Sum with its own organization, unless otherwise approved by the Director. Any items set forth in the Proposal to be "specialty items" may be performed by subcontract and the cost of any such specialty items so performed by sub-contract may be deducted from the Contract Sum before computing the amount of work required to be performed by the Contractor's own organization. The Contractor's percentage of the Contract Sum includes the cost of materials and manufactured products purchased by the Contractor, but not the cost of materials and manufactured products purchased by subcontractors. The Engineer will calculate the Contractor's percentage based on the quantities shown in the Proposal and the unit prices of the Contract items to be performed by the Contractor's organization.

All subcontractors must hold a valid contract compliance certification number before the City will approve the subcontractor pursuant to this Section.

108.02 Preconstruction Conference. Unless otherwise provided for in the Contract Documents, no Work shall be commenced under this Contract until the Contract is fully executed and a Notice to Proceed has been issued.

The Preconstruction Conference shall not occur until after the Contract is fully executed. In general, fourteen days are required to notify all interested parties of a Preconstruction Conference. The Contractor shall take note of this requirement and aid in the timely scheduling of the Preconstruction Conference to avoid unnecessary delays in the commencement of the Work.

At or before the Preconstruction Conference, the Contractor shall submit, to the Engineer, the baseline construction schedule prepared according to 108.03. The Contractor shall furnish a list of proposed subcontractors and material suppliers at or before the Preconstruction Conference. If the

Contractor fails to provide the required submissions at or before the Preconstruction Conference, the Engineer may order the Preconstruction Conference suspended until they are furnished.

108.03 Prosecution and Progress.

The City of Columbus Project Management Information System (PMIS) will be utilized and required for managing submittals, RFPs, RFIs, and other relevant construction information as determined by the City. Paper copies of Maintenance and Operations are required. Sample submittals cannot be made electronically. The Contractor will be given access to the PMIS and the City will provide guidelines for use of the PMIS.

Pursue the Work diligently and continuously as to complete the Project by the Completion Date. The Construction Schedule shall reflect the Contractor's detailed construction plan to be implemented during all phases of the construction process, Notice to Proceed to final completion. The approved Construction Schedule also serves as a means for the Contractor to schedule, coordinate and evaluate the work of its subcontractors and suppliers. The Contractor is required to include and involve all subcontractors and suppliers in the development and updating of the Construction Schedule. The Contractor shall produce schedule updates and reports to analyze project progress and current status and shall be prepared to respond to reasonable requests from the Engineer for additional information.

Unless a specific Pay Item is included in the Proposal, the cost of preparation of the Construction Schedule, progress updates, and other schedule related information requested by the Engineer is to be included within the Contractor's bid prices for the various pay items.

Failure to comply with Project scheduling requirements may be grounds for termination of the Contract. In addition, the City may withhold pay estimates until all scheduling requirements, including providing schedule updates, are met and accepted by the Engineer.

When a pay item for a CPM schedule is included in the Bid Documents, use Type B – Critical Path Method (CPM) Schedule. Otherwise, all projects shall be scheduled using the Type A – Basic Construction Schedule.

A. Basic Construction Schedule (Type A).

1. Initial/Baseline Construction Schedule Submission. The Contractor shall submit to the Engineer at or before the Preconstruction Conference a baseline bar chart construction schedule and written narrative describing the sequence of construction, and critical events including delivery of materials, services, or equipment.

The Engineer will review the schedule and within seven calendar days of receipt, will either accept the schedule or provide the Contractor with written comments. Acceptance of the schedule does not revise the Contract Documents. Provide clarification or any needed additional information within seven calendar days of a written request by the Engineer. The City will withhold pay estimates until the Engineer accepts the schedule.

The Contractor shall provide a working day schedule that shows the various activities of Work in sufficient detail to demonstrate a reasonable and workable plan to complete the Project by the Completion Date. Show the order and the sequence for accomplishing the Work. Describe all major activities in sufficient detail so that the Engineer can readily identify the Work and measure the progress. The bar chart schedule must reflect the scope of work, required phasing, maintenance of traffic, interim completion dates, final Completion Date, and other project milestones established in the Contract Documents. Include activities for major submittals, as provided in 105.02, major material procurement and fabrication, and the delivery of key materials, plant, and equipment, and other similar activities. The schedule must be detailed on letter or 11" x 17" sized paper.

2. Completion Date. The baseline construction schedule shall not indicate a completion date that is earlier than the Contract Completion Date.

3. Monthly Progress Updates. Prior to the 5th of every month, submit an updated schedule that includes the following:

a. Date that all progress is being recorded through;

b. Actual start date of progressed activities;

c. Actual finish date of completed activities; and

d. Actual percent complete for each progressed activity.

4. Changed Conditions Reporting.

a. Schedule Revisions. If the Contractor's operations are materially affected by changes in the Work plan or in the amount of the Work or if the Contractor has failed to comply with the approved Construction Schedule, the Contractor shall submit a revised construction schedule. The revised schedule shall show how the Contractor proposes to prosecute the balance of the Work. All schedule revisions are subject to the Engineer's approval.

b. Recovery Schedules. If the Monthly Update Schedule or Revised Monthly Update Schedule projects a finish date for the Project later than the current Completion Date, submit a recovery schedule showing a plan to finish by the current Completion Date as requested by the Engineer, at no additional cost to the City. Such measures to regain the schedule may include, but are not limited to, increasing the size of the workforce; increasing the number of working hours per shift, shifts per work day, work days per week, the amount of equipment or combination thereof; or rescheduling of work activities to achieve maximum concurrence of work efforts, all at no additional cost to the City. The Contractor shall submit the recovery schedule within five calendar days after the request is made by the Engineer.

The City will withhold Estimates until the Engineer approves the recovery schedule. The approved Recovery Schedule will supersede the then-current Construction Schedule and be used as the basis for progress evaluations. Acceptance by the City of the recovery schedule and/or recovery plan shall not serve as a time extension approval.

c. Delay and Analysis of the Construction Schedule. The Contractor shall not be entitled to and hereby waives any extension of time resulting from any event, circumstance, condition or cause unless a Claim for an extension of time is made in accordance with the requirements of 104.03. In the event the Contractor requests an extension of the Contract Time, it shall furnish such justification and supporting evidence as the Engineer may deem necessary for a determination of whether or not the Contractor is entitled to an extension of time under the provisions of the Contract.

The written claim seeking an extension of time must include the following information:

i. Nature of the delay.

ii. Date (or anticipated date) of commencement of delay.

iii. Identification of person(s) or organization(s) or events affected by delay.

iv. Activities on the Construction Schedule affected by the delay, or new activities created by the delay and their relationship with existing activities.

v. Identification of person(s) or organization(s) or event(s) the Contractor believes responsible for the delay.

vi. Anticipated extent of the delay.

vii. Recommended action to avoid or minimize the delay.

viii. Identification of the pertinent contract provisions and supporting documents or project records.

Any request for an extension of the Contract Completion Date must be processed per 108.06. If there is a time extension request pending, the Contractor shall not include the time extension in a monthly progress update until the request is approved by the City and shall not use the time extension request as a basis for refusing to prepare and submit a recovery schedule.

B. Critical Path Method (CPM) Schedule (Type B).

The Contractor shall submit to the Engineer a baseline construction schedule as described in 108.03.B.1 in the form of a computer generated CPM Schedule in a format approved by the Engineer or as specified. The Contractor shall designate a Scheduler(s) who shall be responsible for preparing and maintaining the schedule and coordinating with the Engineer. The Contractor shall provide personnel or a subcontractor specializing in CPM scheduling with experience in scheduling at least three projects of a similar complexity to the Project. If requested by the Engineer, provide at the preconstruction meeting the experience and qualifications of the scheduler(s).

The CPM Construction Schedule shall clearly show the sequence of work and interdependence of activities by utilizing predecessor and successor relationships.

1. Initial/Baseline Construction Schedule Submission. The Contractor shall submit a baseline schedule within fifteen calendar days from the Notice to Proceed. The baseline schedule will be in CPM format and as described herein. The baseline construction schedule shall provide a complete and detailed sequence of operations of the work within the time limits specified in the Contract. The baseline construction schedule shall show the order in which the Contractor proposes to carry out the work, the dates on which the various portions of the work shall commence, and the dates on which the Contractor contemplates completing the Work.

In addition to providing the baseline construction schedule, the Contractor shall provide an initial work plan narrative containing the following: the planned number of crews, crew type, approximate crew size, and equipment.

The Engineer will review the baseline schedule and will provide a disposition of the schedule within fourteen calendar days of receipt. The Engineer's review of the baseline schedule will be for compliance with the Specifications and Contract requirements. Approval by the Engineer shall not relieve the Contractor of any of its responsibilities for the accuracy or feasibility of the schedule.

For baseline schedules that are not accepted, the Engineer shall indicate in writing all portions of the schedule that are not in compliance with the Contract requirements. The Contractor shall make the necessary revisions and resubmit the revised schedule within seven Calendar Days. The Engineer will reject baseline schedules that are not in compliance with Contract requirements.

The Engineer shall conduct a mandatory meeting with the Contractor and the Contractor's Schedule Representative within seven calendar days of the Engineer's written notice for any baseline schedule that is not accepted. The purpose of this meeting is to resolve issues with the baseline schedule. At this meeting the Contractor shall provide clarification and additional information necessary for the Engineer to accept the baseline schedule.

The City shall withhold pay estimates until the baseline schedule is "accepted".

Acceptance of the baseline schedule does not revise the Contract Documents.

a. Schedule Requirements. Generate the baseline schedule using Oracle Corporation's Primavera P6 Project Management or the latest version of Oracle Primavera Software.

Provide a working day schedule that shows the various activities of work in sufficient detail to demonstrate a reasonable and workable plan to complete the Project by the Contract Completion Date. Show the order and interdependence of activities and the sequence for accomplishing the Work. Describe all activities in sufficient detail so that the Engineer can readily identify the elements of the Work and measure the progress of each activity. The baseline schedule must reflect the scope of work, required phasing, maintenance of traffic requirements, interim completion dates, the Completion Date, and other project milestones established in the Contract Documents. Include activities for major submittals,

working drawings, shop drawings, submittal review time for the City, material procurement and fabrication, and the delivery of materials, plant, and equipment, and other similar activities.

The Contractor shall be responsible for assuring all work, including all subcontractor and supplier work, is included in the schedule. The Contractor shall be responsible for assuring that all work sequences are logical and that the schedule indicates a coordinated plan.

Failure by the Contractor to include any element of Work required for performance of the Contract shall not excuse the Contractor from completing all Work by the Completion Date. Omissions and errors shall be corrected as described in 108.03.B.4.a and will not affect Contract Time.

b. CPM Schedule Format.

i. Administrative Identifier Information: The following information should be included in the title bar on all schedule sheets:

a. Project Number

b. Project Name

c. Project Location

d. Data Date

e. Completion Date

f. Contractor's Name

ii. Project Activities shall represent an uninterrupted action, task, component, process or operation and include the following:

a. Activity Identification (ID). Assign each activity a unique identification number. Activity ID length shall not exceed 10 characters. Once accepted, the Activity ID shall be used for the duration of the project.

b. Activity Description. Each activity shall have a narrative description consisting of a verb or work function (e.g.; form, pour, excavate) and an object (e.g.; slab, footing, underdrain).

c. Activity Original Duration. Activity Original Duration is defined as the amount of time required to complete the activity based on a set of planned resources necessary to complete the activity. Assign a planned duration in working days for each activity. Do not exceed a duration of 20 working days for any construction activity unless approved by the Engineer. Do not represent the maintenance of traffic, erosion control, and other similar items as single activities extending to the Completion Date. Break these Pay Items into component activities in order to meet the duration requirements of this paragraph.

d. Activity Relationships:

1. All activities, except the first activity, shall have a predecessor(s). All activities, except the final activity, shall have a successor(s).

2. Use only finish-to-start relationships with no leads or lags to link activities.

3. No activity shall involve more than one trade or specialty subcontractor. There is to be at least one activity for every subcontractor performing work on the Project.

4. Provide activities for procurement of major equipment and any other long lead time items.

5. Any activity durations that are based on something other than a single shift operation are to be clearly and individually identified with an appropriate explanation of how those multi-shift activities relate to the other schedule activities. Shift work needs to be consistently addressed either in an activity ID and/or in an activity code. The schedule is considered to be based on an eight hour day, five day work-weeks unless otherwise noted.

iii. Project Milestones: Milestones shown in the Contract Documents shall be included in the Baseline Schedule. Milestone dates may be modified only by Change Order or Contract Modification. In addition to any milestones identified in the Contract Documents, include the following milestones in the schedule:

a. Start Project Milestone: The Contractor shall include as the first milestone in the schedule, a milestone named "Start Project". The date used for this milestone is the date provided in the Notice to Proceed.

b. End Project Milestone: The Contractor shall include as the last activity in the project schedule, a milestone named "End Project". The date used for this milestone is considered the project completion date.

c. Start Phase Milestone: The Contractor shall include as the first activity for a project phase, an activity named "Start Phase X", where "X" identifies the phase of work.

d. End Phase Milestone: The Contractor shall include as the last activity in a project phase, an activity named "End Phase X" where "X" identifies the phase of work.

The Contractor may include additional milestones.

iv. Level of Effort Activities: Use level of effort activities to show the duration of specified contract work periods, phases and road closures. The level of effort activity type is allowed to have a start-to-start relationship with the first activity in a series of activities and a finish-to-finish relationship with the last activity in a series of activities.

v. Constraints: The Construction Schedule is to have no constrained activities except the Start Project Milestone and the End Project Milestone dates, unless otherwise permitted by the Engineer. Interim dates are to be controlled by logic and activity duration only. Mandatory start and finish constraints are not to be used in the schedule.

vi. Seasonal Weather Conditions: Anticipated weather days outlined in the Table 108.07-1 identify the number of days each month the Contractor must plan for weather impacts. Seasonal weather conditions shall be considered and included in the planning and scheduling of all Work in accordance with Table 108.07-1.

Anticipated weather days specified in Table 108.07-1 shall be incorporated in the schedule using work calendars. In the baseline schedule, random non-sequential weekdays shall be considered non-workdays to match the anticipated weather days total for that month according to 108.07. Anticipated weather days must be the same dates on all calendars affected by weather. Subsequent schedule updates shall remove the random weather days and replace them with the actual agreed weather days at no additional cost to the City. The winter shutdown periods shall be shown using non-work calendars. The activity can be assigned to a calendar indicating time periods of non-work. These custom calendars can be created to show days, weeks, or months of non-work. Seasonal weather conditions shall be considered and included in the planning and scheduling of all work.

vii. Linking Projects: Independent projects shall not be linked.

viii. Activity Codes: The Contractor shall, at a minimum, include codes for Area, Phase, and Responsibility for each activity. At the Engineer's approval, the Contractor may use a Work Breakdown Structure (WBS) to organize the construction schedule.

ix. Schedule Options: The schedule may only be calculated using actual dates. Schedule durations are to be contiguous. Total float shall be calculated as finish float. All activities must have a predecessor/successor relationship except for the first activity (Project Start) and the last activity (Project Finish).

x. Calendars: All calendars are to be based on a five day work-week and activity durations are to be in working days unless otherwise approved by the Engineer. Calendars are to include any recognized Holidays (when observed) that will shorten a five working-day week. The construction schedule shall include multiple calendars appropriate to the activity (i.e. 7 day calendar for cure time, burn–in time, settlement period, etc). Calendars should reflect weather restrictions for certain work (i.e. asphalt, painting, etc.).

c. Completion Date. The baseline construction schedule shall not indicate a completion date that is earlier than the Contract Completion Date.

d. Submission Requirements. Submit all schedules within the time frames specified. Submit the schedule and information in electronic file format.

Submit the following information along with the electronic baseline schedule:

i. A baseline schedule in a bar chart format, including the Administrative Identifier Information on the first page of the schedule. For each activity on the chart, indicate the Activity ID, Activity Description, Original Duration, Remaining Duration, Total Float, Early Start Date, Early Finish Date, and Calendar ID. Use arrows to show the relationships among activities.

ii. A baseline schedule in a bar chart format, on paper. Identify the critical path of the project on the bar chart in red. The critical path is defined as; the longest path of activities in the project that determines the project completion date. The activities that make-up the critical path of activities are the "Critical Activities."

iii. A Six Week Look Ahead Schedule in bar chart format. This schedule will have all the requirements of the baseline schedule in bar chart format except that it shall be limited to those activities that have an early start or early finish within a six week period of the data date.

iv. A Scheduling Statistics Report. Submit a report of baseline schedule statistics, including number of activities, number of activities on the longest path, number of started activities, number of completed activities, number of relationships, percent complete, and number and type of constraints.

v. A Logic Diagram (If requested by the Engineer). Submit a diagram in PERT chart format showing the logic of the baseline schedule.

vi. An Activity ID Sort. Submit a listing of all activities included in the baseline schedule sorted by ascending Activity Identification Number.

vii. A Total Float Sort. Submit a listing of all activities included in the baseline schedule sorted by increasing total float and by early start date.

viii. A Detailed Predecessor/Successor Sort. Submit a listing of all activities included in the baseline schedule indicating the activities that immediately precede and immediately succeed that activity in the schedule logic.

2. Float. Float is not time for the exclusive use or benefit of either the City or the Contractor but is to be a shared commodity to be reasonably used by either party to mitigate delay to the Contract Completion Date.

Pursuant to the float sharing requirements of this Section, the use of float suppression techniques such as: preferential or logic sequencing (arranging critical path through activities more susceptible to City caused delay); special lead/lag restraints; extended activity durations; as late as possible constraints; imposed constraint dates other than those required by the Contract Documents; and the like are prohibited and shall be cause for rejection of the project schedule or its updates.

a. Definitions of Float: "Float" is defined as the amount of time between the early start date and the late start date (or the early finish date and late finish date) of any activity in the Construction Schedule. "Total Float" is defined as the amount of time any given activity or path of activities may be delayed before it will affect the Contract Completion Date. Project Float is the length of time between the End Project Milestone and the Contract Completion Date.

b. Ownership of Float: Float available in the schedule, at any time, shall not be considered for the exclusive use of either the City or the Contractor. During the course of contract execution, any float generated due to the efficiencies of either party is not for the sole use of the party generating the float; rather it is a shared commodity to be reasonably used by either party. Efficiencies gained as a result of favorable weather within a calendar month, where the number of days of normally anticipated weather is less than expected, will also contribute to the Project Float. A monthly progress update schedule showing work completing in less time than the contract time, and accepted by the City, will be considered to have Project Float. Project Float will be a resource available to both the City and the Contractor. No time extensions will be granted nor delay damages paid unless a delay occurs which impacts the Project's critical path, consumes all available float and extends the work beyond the Contract Completion Date.

c. Negative Float: Negative float will not be a basis for requesting time extensions. Any extension of time will be addressed in accordance with 108.03.B.4.c. Scheduled completion date(s) that extend beyond the Contract (or phase) Completion Date(s) may be used in computations for assessment of liquidated damages. The use of this computation shall not be construed as an order by the City to accelerate the Work.

3. Monthly Progress Updates. Prior to the 5th of every month, submit an updated schedule with a data date of the last day of the previous month, unless a different date is agreed to by the Engineer. A monthly update schedule is a schedule in which only progress is updated from the prior data date to the current data date. Work added and/or excusable delays encountered since the prior data date must be represented as a schedule revision as described in 108.03.B.4.a.

a. Update Requirements.

i. Submit the monthly updated bar chart on paper and a copy of the updated schedule in electronic file format. The Engineer shall accept or not accept the schedule update within seven calendar days of receipt of the updated CPM schedule.

ii. Correct out-of-sequence progress listings generated by the Scheduling Statistics Report as directed by the Engineer.

iii. Maintain schedules to record actual start and finish dates of completed activities on a weekly basis until otherwise notified by the Engineer.

iv. Identify the actual start date and remaining duration for all activities in progress. Indicate progress of each activity to date of revision using remaining duration, not percent complete.

v. Show accumulated percentage of completion of each item for updates, and total percentage of Work completed, as of the schedule's data date.

b. Submit the following with each updated schedule:

i. CPM Schedule in Bar Chart Format - Two large printed copies, minimum 22" X 34"

ii. Two Week Look Ahead CPM Schedule in Bar Chart Format

iii. Logic Diagram (If requested by the Engineer)

iv. Activity ID Sort (If requested by the Engineer)

v. Total Float Sort (If requested by the Engineer)

vi. Detailed Predecessor/Successor Sort (If requested by the Engineer)

vii. Schedule Statistics Report

viii. Electronic files of the Primavera Project files in .xer

c. Provide two printed copies of a Narrative Status Report that includes the following:

i. A description of the general status of the Work.

ii. Any outstanding issues that affect the construction schedule, i.e., any current and anticipated delaying factors, and describe their impact on the construction schedule, the critical path and the Project Completion Date.

iii. Any activities added to the construction schedule with an explanation for their addition.

iv. Any activities deleted from the construction schedule with an explanation for their deletion.

v. Any changes in the relationships of activities with an explanation.

vi. Any changes to worker hours or budgeted costs with an explanation.

vii. An explanation of any recovery measures being taken.

The Contractor may submit a statement that there were no changes in the schedule logic, activity durations, or calendars since the previous update in lieu of submission of items iii, iv, v, and vi.

d. Estimates will not be processed unless all schedule requirements are met.

e. Early Completion Monthly Update Schedule. In the event that an accepted monthly progress update indicates a completion date that is earlier than the Contract Completion Date, the Contractor shall not be entitled to any extension in Contract time or recovery of any cost for delay, disruption, interference, hindrance, extension, or acceleration costs incurred, however caused, because of an extension of the early completion date until such time as the network or activities affected increases the critical path duration of the CPM Schedule beyond the Contract Completion Date.

f. Late Completion Monthly Update Schedule. A Late Completion Monthly Update Schedule is defined as a monthly update schedule submitted by the Contractor in which the Finish Date exceeds the Contract Completion Date. A Late Completion Monthly Update Schedule will require the preparation and submission of a Recovery Schedule under 108.03.B.4.b.

g. The project schedule shall be reviewed at each progress meeting.

h. Any corrections to the schedule shall be made and submitted to the Engineer within seven calendar days.

4. CPM Changed Conditions.

a. Schedule Revisions. If the Contractor's operations are materially affected by changes in the Work plan or in the amount of the Work or if the Contractor has failed to comply with the approved Construction Schedule, the Contractor shall submit a revised construction schedule, which the schedule shall show how the Contractor proposes to prosecute the balance of the Work.

Any addition of new activities or new calendars or changes to existing activities, calendars or logic constitutes a revision. All revisions must be reported in narrative form on a cover sheet accompanying the monthly update schedule. The schedule revision must be accompanied by a narrative detailing the changes in logic, activities, and durations from the accepted baseline.

Any revision which modifies the critical path or impacts an interim date or project completion date must be represented on a companion schedule submitted with the monthly update schedule or as a fragnet within the monthly update schedule. A fragnet is defined as the sequence of new activities that are proposed to be added to the existing schedule. The fragnet shall identify the predecessors to the new activities and demonstrate the impacts to successor activities. If submitted as a fragnet, the Contractor shall compute two Finish Dates. The first Finish Date shall be computed without consideration of any impact by the fragnet. The second Finish Date shall be computed with consideration of any impact by the fragnet. The Contractor shall also submit a written narrative stating the reason for the proposed revisions. The Engineer shall "approve" or "reject" proposed revisions within ten days of receipt of appropriate schedules and narrative. All approved revisions will be incorporated into the Monthly Update Schedule which will become the Revised Monthly Update Schedule.

b. Recovery Schedules. If the Monthly Update Schedule or Revised Monthly Update Schedule projects a finish date beyond the Completion Date, submit a recovery schedule showing a plan to finish by the current Completion Date if requested by the Engineer, at no additional cost to the City. The recovery schedule shall also include a written plan detailing how the Contractor proposes to recover the lost time and meet the Completion Date. Such measures may include, but are not limited to, increasing the size of the workforce; increasing the number of working hours per shift, shifts per work day, work days per week, the amount of equipment or combination thereof; or rescheduling of work activities to achieve maximum concurrence of work efforts, all at no additional cost to the City. The Contractor shall submit the recovery schedule within ten days after the request is made by the Engineer.

The City may withhold Estimates until the Engineer approves the recovery schedule. The Engineer will use the schedule to evaluate time extensions and associated costs requested by the Contractor. In the event the current Completion Date is in dispute, the recovery schedule must be submitted once the dispute has been resolved.

The Engineer will review the Contractors' revised plan and provide comments. The Contractor is to incorporate or resolve all such comments to the satisfaction of the Engineer. At that time, the revised Construction Schedule will supersede the then-current Construction Schedule and be used as the basis for progress evaluations. Acceptance by the City of the revised construction schedule and/or recovery plan shall not serve as a time extension approval.

c. Delay and Analysis of the Construction Schedule. The Contractor shall not be entitled to and hereby waives any extension of time resulting from any event, circumstance, condition or cause unless a request for an extension of time is made in accordance with the requirements of 104.03. In the event the Contractor requests an extension of the Contract Time, it shall furnish such justification and supporting evidence as the Engineer may deem necessary for a determination of whether or not the Contractor is entitled to an extension of time under the provisions of the Contract.

Any request for an extension of the Contract Completion Date must be processed per 108.06. If there is a time extension request pending, the Contractor shall not include the time extension in a monthly progress update until the request is approved by the City and shall not use the time extension request as a basis for refusing to prepare and submit a recovery schedule in accordance with this Section. The City may withhold pay estimates until the progress schedule, revised progress schedule and/or recovery plan is approved by the City. Should the prosecution of the Work, for any reason, be discontinued, the Contractor shall notify the Engineer at least one Work Day in advance of resuming operations.

Submit the impacted schedule with the request for time extension. Include a narrative report describing the effects of new activities and relationships to interim and contract completion dates. The written claim seeking an extension of time must include the following information:

i. Nature of the delay.

ii. Date (or anticipated date) of commencement of delay.

iii. Identification of person(s) or organization(s) or events affected by delay.

iv. Activities on the Construction Schedule affected by the delay, or new activities created by the delay and their relationship with existing activities.

v. Identification of person(s) or organization(s) or event(s) responsible for the delay.

vi. Anticipated extent of the delay.

vii. Recommended action to avoid or minimize the delay.

viii. Identification of the pertinent contract provisions and copies of applicable documents and project records.

ix. Show the impact of the delay on the Critical Path by comparing the original longest path to the current longest path that incorporates the delay.

The determination of the total number of days' extension shall be based upon the most recently approved Schedule Update as of the start of the delay claimed by the Contractor and on all data relevant to the extension. Circumstances and activities leading to such claim shall be indicated or referenced in the Contractor's daily field report for the day(s) affected.

Perform the following analysis to compute the duration of the time extension. Submit two paper copies and two electronic copies of each analysis performed.

i. Determine project progress prior to circumstance(s) necessitating the time extension. Provide an interim schedule updated to the date of the circumstance alleging to have caused delay. This schedule is referred to as the Un-impacted Schedule.

ii. Prepare a fragmentary network (fragnet) depicting the circumstance that is believed to have delayed the project.

iii. Insert the fragnet into the Un-impacted Schedule, run the schedule calculations and determine the finish date. This schedule is referred to as the Impacted Schedule.

iv. Compare the Impacted Schedule finish date with the Un-impacted Schedule finish date in order to determine the duration of any warranted time extension.

All approved time extensions will be incorporated into the monthly update with the fragnet used to determine impacts incorporated into the schedule.

C. Basis of Payment.

No separate payment will be made for Type A schedules and the cost of such schedule shall be included in the prices bid for the various Pay Items of the Contract.

The City will make payments for Type B Schedules according to 109.07 and as modified by the following schedule:

1. The City will release 60 percent of the lump sum amount bid for CPM Progress Schedule to the Contractor with the first regular estimate payable after the Engineer has approved the CPM Baseline schedule submission.
2. The City will release an additional 30 percent of the lump sum amount bid for CPM Progress Schedule to the Contractor with the first regular estimate payable after 50 percent of the original contract amount is complete.
3. The City will release the remaining 10 percent of the lump sum amount bid for CPM Progress Schedule to the Contractor with the first regular estimate payable after 90 percent of the original contract amount is complete.

The City will pay for the accepted quantities at the contract price as follows:

Item	Unit	Description
108	Lump Sum	Type B CPM Progress Schedule

108.04 Limitation of Operations. The Contractor shall conduct the Work at all times in such a manner and in such sequence as will assure the least interference with traffic and other operations of the City and the public. The Contractor shall conduct the Work with due regard to the location of detours and to the provisions for handling traffic. The Contractor shall not open up work that would interfere with other work or operations already started or adversely impact work that is already partially completed. The Engineer may require the Contractor to finish a section on which work is in progress before work or operations are started on any additional sections if the completion and opening of such section is essential to public convenience.

A. Work Hours. All Work shall be performed only during the period from 1/2 hour before sunrise and 1/2 hour after sunset as sunrise and sunset are determined by the U.S. National Weather Service.

B. Night Work, Work on Sunday and National Holidays. Authorization to work at night, on Sunday and/or National Holidays shall only be upon written permissions of the Engineer or as detailed in the Contract Documents. Requests to work at night, on Sunday and/or National Holidays must be made in writing three working days prior to the night, Sunday and/or Holiday work.

The Contractor is advised, however, that if permission is granted by the Engineer, all work at night, on Sunday and/or National Holidays must be in accordance with the City's Noise Ordinance unless such requirements have been waived by action of the Director.

If authorization to work at night is provided as specified in 108.04.B, the Contractor must provide 24 hour notice to cancel this work. If such notification is not provided, the Contractor cancelling work will be required to pay the City inspection fees for eight (8) hours of the inspector's time at the current billing rate.

108.05 Character of Workers, Methods, and Equipment.

A. Labor, Materials and Equipment. The Contractor shall at all times employ sufficient competent labor, materials and equipment for prosecuting the Work to completion in the manner, method, sequence and time required by the Contract Documents. All workers shall have sufficient skill and experience to perform properly the work assigned to them. Workers engaged in special work or skilled work or operations shall have sufficient experience in such work and in the operation of the equipment required to perform all work properly and satisfactorily.

B. Personnel. Any person employed by the Contractor or by any subcontractor who, in the opinion of the Engineer, does not perform their work in a proper and skillful manner or is intemperate or disorderly shall, at the written request of the Engineer, be removed forthwith by the Contractor or its subcontractor employing such person, and shall not be employed again in any portion of the Work without the approval of the Engineer.

C. Equipment. All equipment that is proposed to be used on the Work shall be of sufficient type and size and in such mechanical condition as to meet the requirements of the Contract and produce a satisfactory quality of Work. Equipment used on any portion of the Work shall be such that no injury to workers, the public, the roadway, adjacent property, or other streets or highways will result from its use.

When the methods and equipment to be used by the Contractor in accomplishing the Work are not prescribed in the Contract, the Contractor may use any methods or equipment that is demonstrated to the satisfaction of the Engineer and will accomplish the Work in conformity with the requirements of the Contract.

When working or staging on existing pavements that are not included in the contract for replacement or resurfacing, the Contractor shall select equipment and sequences such that the existing pavements are not further degraded by the Work. If the Contractor uses any equipment that results in additional degradation of the pavements, then the Contractor agrees that all pavements degraded from his Work shall be resurfaced or replaced as determined by the Engineer at no additional cost to the City, regardless of whether the use of the equipment increases efficiency or production.

When the Contract specifies that the Work be performed by the use of certain methods and equipment, such methods and equipment shall be used unless others are authorized in writing by the Engineer. If the Contractor desires to use a method or type of equipment other than those specified in the Contract, the Contractor may request authority from the Engineer to do so. The request shall be in writing and shall include a full description of the methods and equipment proposed to be used and an explanation of the reasons for requesting to make the change. If approval is given, it will be on the condition that the Contractor will be fully responsible for producing Work in conformity with Contract requirements. If, after trial use of the substituted methods or equipment, the Engineer determines that the work produced does not meet Contract requirements, the Contractor shall discontinue the use of the substitute methods or equipment and shall complete the remaining Work with the Contract specified methods and equipment. The Contractor shall remove all deficient Work and replace it according to the Contract Documents, or take such corrective action as directed by the Engineer. The Contractor agrees that the substitution of methods and equipment shall not be a basis for any Claim seeking additional cost or time.

D. Withholding of Payment. Should the Contractor fail to furnish sufficient competent personnel, materials and equipment for the proper prosecution of the Work, or fail to remove such person(s) as requested by the Engineer, the Engineer may withhold all pay estimates, which are or may become due.

108.06 Determining a Time Extension to the Completion Date and Payment for Excusable Delays.

A. General. The City will extend the Completion Date only for (i) excusable delays as specified in 108.06.B or 108.06.D that (ii) delay Work on the critical path as shown on the accepted progress schedule and (iii) impact the Completion Date. For purposes of this Section, the critical path is defined as the longest path of activities in the Project that determines the Completion Date. Any delay that is not on the critical path of the Project shall not be excusable or compensable.

The City will not evaluate a request for extension of the Completion Date unless the Contractor notifies the Engineer consistent with the process and timelines as specified in 104.03. In the event that the Contractor does not know the extent of the delay at the time of the first written notice, it shall supplement its notice and schedule analysis per 104.03, 108.03.A.4.c and 108.03.B.4.c as it becomes aware of the extent of the delay for which it is requesting a time extension.

If the Contractor contends that an excusable delay is also compensable as specified in 108.06.D, the Contractor shall also submit a detailed cost analysis of the requested additional compensation in accordance with 109.05 along with the request for an extension of the Completion Date.

The Contractor is responsible for mitigating any delay, whether caused by the City, the Contractor, its subcontractors or suppliers, a third party, or an intervening event. Mitigation efforts may include, but are not limited to, re-sequencing work activities, acceleration, and continuation of work through an otherwise planned shutdown period. The Contractor and the Engineer shall work cooperatively with one another to explore and implement mitigation efforts in a timely manner.

The Engineer will measure all time extensions in Calendar Days. The Engineer will not grant an extension of time for delays incurred from December 1 to April 30 unless the Contractor's accepted progress schedule shows work on the critical path occurring during this period. The Engineer may order the Contractor to continue the Work after November 30 and compensate the Contractor for additional costs incurred due to cold weather work during the period from December 1 to April 30.

If the Engineer extends the Completion Date pursuant to 108.06, the City will excuse the Contractor from corresponding liquidated damages as specified in 108.07.

B. Excusable, Non-Compensable Delays. Excusable, non-compensable delays are critical path delays that are not the City's or the Contractor's fault or responsibility. If the conditions in 108.06.A are met, the Engineer will extend the Completion Date only for the following excusable, non-compensable delays:

1. Delays due to floods, tornadoes, lightning strikes, earthquakes, or other cataclysmic phenomena of nature.
2. Delays due to weather as specified in 108.06.C.
3. Extraordinary delays in material deliveries the Contractor or its suppliers cannot foresee or avoid resulting from freight embargoes, government acts, or industry-wide and area-wide material shortages. Delays due to the Contractor's, subcontractor's, or supplier's insolvency, actions or omissions, or mismanagement are not excusable.
4. Delays due to civil disturbances.
5. Delays from fires or epidemics.
6. Delays from labor strikes that are beyond the Contractor's, subcontractor's, or supplier's power to settle and are not caused by improper acts or omissions of the Contractor, subcontractor, or supplier.
7. Added quantities that delay an activity on the critical path.
8. All other delays to the critical path that are not the Contractor's or the City's fault or responsibility.

C. Extension to the Completion Date for Weather or Seasonal Conditions. The Contractor shall be entitled to a non-compensable extension of the Completion Date caused by weather days only as permitted in 108.06.C. A weather day is defined as a Work Day on which weather or seasonal conditions reduced production by more than fifty percent on items of work on the critical path as defined by 108.06.A; provided, however, Sundays and Holidays will not be counted as lost Work Days. Delays caused by weather or seasonal conditions should be anticipated by the Contractor. The following Table 108.06-1 of monthly anticipated abnormally inclement weather delays is based on National Oceanic and Atmospheric Administration (NOAA) or other similar data for Columbus, Ohio and will constitute the baseline for monthly inclement weather evaluations. The Construction Schedule must reflect these anticipated adverse weather delays in all weather-dependent activities. Inclement weather will be considered as the basis for an extension of the Completion Date only when the actual Work Days lost due to inclement weather exceeds the anticipated number of inclement weather days as shown in the following table:

TABLE 108.06-1 MONTHLY ANTICIPATED INCLEMENT WEATHER DELAY TABLE

(Work Days Based on a Five Day Work Week)

January	15
February	12
March	7
April	6
May	6
June	5
July	4
August	4
September	5
October	6
November	6
December	10

This table applies to the duration between Notice to Proceed and original Completion Date. Extensions for weather days beyond the original Completion Date will be determined in accordance with 108.06.C.

The Engineer will not extend the Completion Date for work days lost from December 1 to April 30, unless the Contractor's accepted progress schedule depicts Work on the critical path occurring during the period from December 1 to April 30 and the number of weather days is in excess of those listed above for the period from December 1 to April 30.

D. Excusable, Compensable Delays. Excusable, compensable delays are critical path delays that are not the Contractor's fault or responsibility and are the City's fault or responsibility or are determined by judicial proceeding to be the City's sole responsibility.

If the conditions in 108.06.A are met, the Engineer will extend the Completion Date only for the following excusable, compensable delays:

1. Delays due to revised Work as specified in 104.02.B; 104.02.D; and 104.02 F.
2. Delays due to utility or railroad interference within the Construction Limits that are not the Contractor's responsibility.
3. Delays due to an Engineer-ordered written delay or suspension as specified in 104.02.C.
4. Delays due to acts of the government or a political subdivision other than the City; provided, however, these compensable delay costs are limited to escalated labor and material costs only, as allowed in 109.05.D.2.b and 109.05.D.2.d.

Compensation for excusable, compensable delays will be determined by the Engineer in accordance with 109.05.D.

E. Non-Excusable Delays. Non-excusable delays are delays that are the Contractor's fault or responsibility. All non-excusable delays are non-compensable.

F. Concurrent Delays. Concurrent delays are separate critical path delays that occur at the same time. For all time periods when a non-compensable critical path delay is concurrent with a compensable critical path delay as shown by the schedule analysis performed pursuant to 108.03, the Contractor shall be entitled only to additional time but not entitled to additional compensation.

108.07 Failure to Complete on Time. If the Contractor fails to complete the Work by the Final Completion Date, then the Engineer, if satisfied that the Contractor is making reasonable progress, and deems it in the best interest of the City, may allow the Contractor to continue in control of the Work. If the Contractor is permitted to continue, the Contractor must provide for the Engineer's approval a written work plan and schedule for completion of the Project and shall diligently prosecute the Work in such a manner as required by the Contractor's approved work plan.

If the Contractor fails to complete the Contract Work by the Interim Completion Date, the City will deduct Liquidated Damages according to Table 108.07-1. The amount of Liquidated Damage will be based on the Total Amount of the Bid.

For each Calendar Day that Work remains uncompleted after the Completion Date, the City will deduct the sums specified herein from any money due the Contractor, not as a penalty, but as liquidated damages based on the following schedule:

TABLE 108.07-1 SCHEDULE OF LIQUIDATED DAMAGES

Original Contract Amount (Total Amount of the Bid)		Amount of Liquidated Damages to be Deducted for Each Calendar Day of Overrun in Time
From More Than	To and Including	
$0	$50,000	$150.00
$50,000	$150,000	$250.00
$150,000	$500,000	$500.00
$500,000	$2,000,000	$1,000.00
$2,000,000	$5,000,000	$1,500.00
$5,000,000	$10,000,000	$2,000.00
Over $10,000,000		$2,500.00

If the Contract Documents contain a special provision for liquidated damages, it shall be used in lieu of the schedule listed above.

In addition to the amounts specified above, for each Calendar Day after the Final Completion Date the Contractor will be charged for all City inspection and contract administration services resulting from the delay. The Contractor acknowledges that the liquidated damages set forth above are to compensate the City for its inability to use the Work as scheduled for its intended purpose. The Contractor expressly waives any right to assert or plead that payment of the additional costs for inspection and contract administrative services are duplicative of the liquidated damages set forth above.

The City will continue to pay the Contractor for Work performed on the Project less any liquidated damages set forth in this Section. The City may deduct the liquidated damages and inspection costs from all estimates due and payable to the Contractor after the Final Completion Date.

108.08 Unsatisfactory Progress and Default of Contractor.

A. Termination for Default. The Director will notify the Contractor in writing of unsatisfactory progress and provide a Notice of Intent to Declare the Contractor in Default ("Notice of Default") for any of the following reasons:

1. The Contractor assigns or sublets the Work without approval from the Director.
2. The Contractor makes a material misrepresentation in any of the required Bid or Contract Documents.
3. The Contractor fails to supply a sufficient number of properly skilled workers or proper equipment or materials.
4. The Contractor becomes financially unable to meet its obligations, as evidenced by any of the following: filing for bankruptcy protection, making a general assignment for the benefit of creditors, a receiver is appointed to take charge of the Contractor's affairs, or the Contractor's property is levied or taken in execution or under attachment.
5. The Contractor is not fulfilling or is violating any of the terms of the Contract or fails or refuses to perform or complete the Work.
6. The Contractor is not making such progress in the execution of the Work as needed to meet the Completion Date.
7. The Contractor abandons the Work under the Contract.
8. The Contractor disregards laws, permits, ordinances, codes, rules, regulations or orders of any public authority having jurisdiction or fails to follow instructions of the City.
9. The Contractor repeatedly fails to make prompt payment to subcontractors or suppliers, or for materials and labor.
10. The Contractor has not furnished required schedule(s) or schedule information, or has not commenced or progressed the Work by the dates established in the approved project schedule or updates.
11. Any other reason the Director believes jeopardizes completion of the Work by the Completion Date.

If the Contractor does not respond to the Notice of Default to the satisfaction of the Director, the Director may declare the Contractor in default and issue a Notice of Termination, to the Contractor and terminate the Contractor's employment and notify the Surety and the Contractor

that the responsibility to complete the Contract is transferred to the Surety. Upon receipt of the Notice of Termination the Contractor's right to control and supervise the Work shall immediately cease and the Contractor shall not be entitled to receive any further payment. Upon the receipt of the Notice of Termination, the Contractor shall discontinue the Work or such part thereof as the Director shall designate.

If after default termination pursuant this Section, it is determined that none of the circumstances set forth in 108.08.A exist, then such termination shall be considered a termination for convenience pursuant to 108.08.B. In such event, the Contractor's sole remedy shall be the costs permitted by 109.05.F.

B. Termination for Convenience.

1. General. The City may by written order to the Contractor terminate the Contract or any portion thereof when such termination would be in the best interest of the City.

Any such termination shall be effected by delivery to the Contractor of an Order of Termination specifying that the termination is for the convenience of the City, the extent to which performance of Work under the Contract is terminated, and the effective date of the termination.

2. Contractor Obligations. After receipt of the Order of Termination the Contractor shall immediately:

a. Stop work under the Contract on the date and to the extent specified in the Order of Termination.

b. Place no further orders or subcontracts for materials, services or facilities except as may be necessary for completion of such portion of the Work under the Contract as is not terminated.

c. Terminate all orders or subcontracts for materials, services or facilities except as may be necessary for completion of such portion of the Work under the Contract as is not terminated.

d. Submit to the Engineer a material inventory list ("Materials Inventory"), certified as to quantity and quality of materials in its possession or in transit to the Project.

e. Transfer to the Engineer all completed or partially completed submittals, plans, drawings, information, and other property which if the Contract had been completed would be required to be furnished to the City.

f. Take such actions as may be necessary for the protection and preservation of property related to the Project which is in possession of the Contractor and in which the City has or may acquire an interest.

g. Complete performance of such part of the Work as shall not have been terminated by the Notice of Termination.

3. Materials. Acceptable materials included in the Materials Inventory that have not been incorporated into the Work may, at the option of the City, be purchased from the Contractor and delivered to a location prescribed by the Engineer or otherwise disposed of as mutually agreed.

4. Claim by Contractor. Within ninety days after receipt of the Order of Termination from the City, the Contractor shall submit any Claim for additional damages or costs not covered above or elsewhere in the Contract. The City will meet with the Contractor to reach a settlement acceptable to both the Contractor and the City.

Failure of the Contractor to submit its Claim within the ninety day period will result in the Director's determination of amounts due the Contractor, if any, on the basis of information available, and the City will thereupon pay to the Contractor the amount so determined. Such determination by the Director shall be final and binding and the Contractor expressly waives its right to contest the Director's determination.

5. Continuation of Contractual Responsibilities. Termination of the Contract or a portion thereof shall not relieve the Contractor of its contractual responsibilities for the completed Work and shall not relieve the Contractor's Surety of its obligation for and concerning any claim arising out to the Work performed.

108.09 Certified Payroll. The Contractor shall submit weekly to the Prevailing Wage Coordinator of the City of Columbus a copy of all project employee payrolls for the duration of the time of construction. The copy shall be accompanied by a certified statement, signed by the Contractor or an authorized agent, indicating that the payrolls are correct and complete and that the wage rates contained therein are not less than those required by the prevailing wage rates in the Contract, or any subsequent revision of wage rates during the life of the Contract. The Contractor shall be responsible for the submission of copies of payrolls of all subcontractors.

Provide any additional forms and records as specified in ORC 4115 or as required by Federal law. The Contractor shall make employment records available for inspection by authorized representatives of the City and will permit employees to be interviewed during working hours by these representatives.

All weekly payrolls shall contain or have attached the following:

1. the full name and social security number of each employee;
2. the current address of the employee;
3. the Job Classification of the employee (same as shown on wage determination or provisional approval);
4. the hourly rate of pay;
5. the hours worked each day and total for each week;
6. the fringe payments and deductions made; and
7. the gross and net wages for each week.

Failure to furnish and submit the above information as part of the required weekly Certified Payroll will be cause for the City to withhold the preparation of the monthly estimate. In the event of a violation of the wage rate provisions by the Contractor or any subcontractor, the City may, after notice to the Contractor, suspend further payments or proceed to terminate the Contract as provided by the Contract.

ITEM 109 ACCEPTANCE, MEASUREMENT, AND PAYMENT

109.01 Measurement of Quantities
109.02 Measurement Units
109.03 Scope of Payment
109.04 Compensation for Altered or Eliminated Quantities
109.05 Extra Work
109.06 Directed Acceleration
109.07 Estimates (Partial Payments)
109.08 Project Contingency
109.09 Retainage
109.10 Payment for Material on Hand
109.11 Final Inspection and Acceptance
109.12 Release of Liability
109.13 Guarantee/Warranties
109.14 Backcharges
109.15 Right to Set-Off

109.01 Measurement of Quantities. The City will measure the quantities of Work and calculate payments based on the method of measurement and basis of payment provisions provided in these Specifications. When the following units of measure are specified, the City will measure quantities as described below unless otherwise specified in the Contract Documents.

Lump Sum. Describes payment as reimbursement for all resources necessary to complete the Work. When a complete structure or structural unit is specified as the unit of measurement, the unit will include all necessary fittings and accessories. Partial payments of work bid as a lump sum may be made based upon an agreed percentage of work completed or an approved Schedule of Values.

Each. Measured by the number of individual items of Work completed.

Foot. Measured parallel to the longitudinal base or foundation upon which items are placed, or along the longitudinal surface of the item. Measured vertically to the nearest 0.1 foot.

Square Yard or Square Foot. Measured by a two-dimensional area method on the surface of the item.

Cubic Yard. Measured by a three-dimensional volume method. Measure all "loose material" or material "measured in the vehicle" by the cubic yard. Haul material "measured in the vehicle" in approved vehicles and measure in the vehicle at the point of delivery. For this purpose, use approved vehicles of any type or size satisfactory to the Engineer, provided the vehicle's bed is of such type that the actual contents are readily and accurately determined. Unless all approved vehicles on a job are of uniform capacity, each approved vehicle must bear a legible identification mark indicating the specific approved capacity. The Inspector may reject all loads not hauled in such approved vehicles.

Cubic Yard for Asphalt Concrete. Measure as specified in 401.21.

Acre. Measured by a two-dimensional area method on the surface to the nearest 0.1 acre.

Pound. Measured by actual item net weight avoirdupois.

Ton. The term "ton" means the short ton consisting of 2000 pounds avoirdupois. Weigh all materials that are proportioned by weight on accurate and approved scales that are operated by competent, qualified personnel at locations approved by the Engineer. However, car weights will not be acceptable for materials to be passed through mixing plants. If trucks are used to haul material being paid for by weight, weigh the empty truck at least once daily and as the Engineer directs and only if the weight of the truck is used in determining the ticket weight. Place a plainly legible identification mark on each truck bearing the weight of the truck.

For Work on a tonnage basis, file with the Engineer receipted freight bills for railroad shipments and certified weight-bills when materials are received by any other method, showing the actual tonnage used. For Work on a volume basis, itemize evidence of the volume used.

Gallon. Measured by actual item liquid volume. The City will measure the following materials by the gallon at the following temperatures:

Temperatures	Items
60 °F	Creosote for Priming Coat, Creosote Oil, Creosote Solutions for Timber Preservatives, Asphalt Primer for Water-proofing, and Liquefier
100 °F	RC, MC Asphalt Emulsions, CBAE, Primer 20, and Primer 100
300 °F	Asphalt Binder

Measure tank car outage of asphalt material at its destination before any material has been removed from the tank car according to City Supplement 1060.

Convert the net weight of asphalt material shipments to gallons at the specified pay temperature according to City Supplement 1060.

Convert the gallons at the measured temperature to gallons of asphalt material at the specified pay temperature according to City Supplement 1060.

Thousand Board Feet, MBF. Measure timber by MBF actually incorporated in the structure. Base the measurement on nominal widths, thicknesses, and the extreme length of each piece.

Standard Manufactured Items. When standard manufactured items are specified such as fence, wire, plates, rolled shapes, pipe conduit, etc., and these items are identified by size, unit weight, section dimensions, etc., such identification will be to nominal weights or dimensions set by the industry.

109.02 Measurement Units. The City will measure using English units as indicated in the Contract Documents.

109.03 Scope of Payment. The Contractor shall receive and accept compensation provided for in the Contract as full payment for performing all Work under the Contract in a complete and acceptable manner and for all risk, loss, damage, or expense of whatever character arising out of the nature of the Work or the prosecution thereof, except as otherwise provided in 104.02, 104.03 and 107.16.

Each unit price "Basis of Payment" clause in the Specifications includes any essential work or material described in the Specification unless specifically covered under any other Pay Item.

109.04 Compensation for Altered or Eliminated Quantities. When the accepted quantities of Work vary from the quantities in the Proposal, the Contractor shall accept as payment in full, payment at the original contract unit prices for the accepted quantities of work done, unless a request for an adjustment is made in accordance with 104.02.D.

The adjustment permitted by 104.02.D shall apply only for the quantities in excess of 125% of the estimated quantity stated in the Contract. For those excess quantities, the adjustment shall replace the unit price with a new unit or lump sum price, based upon the reasonable verifiable cost of performance of the excess quantities and calculated in accordance with 109.05.

For decreased quantities below 75% of the estimated quantities in the Contract, the adjustment shall apply to the total actual quantity and shall consist solely of an adjustment for the portion of fixed costs, actually incurred and reasonably allocable to the affected pay item, that the Contractor would have otherwise recovered at the contract unit price if 75% of the estimated quantity had been performed.

The Contract adjustment for payment for eliminated items shall be at the original Contract unit price for such eliminated item, subject to the Contractor making a timely demand for additional adjustment if there is a significant change. The City will not apply a deduction from such payment for maintaining traffic, mobilization, and construction layout stake items for eliminated items, unless there is a significant change as defined by104.02.D.

In no event shall allowances be made for loss of anticipated profits suffered or claimed by the Contractor resulting directly or indirectly from such increased, decreased or eliminated quantities or from unbalanced allocation among the Contract items, or from any other cause.

109.05 Extra Work.

A. General. If the City revises the Contract, the City will pay for changes and Extra Work with a Change Order using the sequence provided in 109.05.B through 109.05.D that constitutes payment in full for all changes and Extra Work.

B. Negotiated Prices. Prior to the Extra Work being performed, the Engineer and the Contractor may negotiate agreed unit or lump sum prices using one or more of the following methods:

1. Original Contract prices for similar work but adjusted for:
   a. increased or decreased material costs.
   b. increased or decreased labor costs.
   c. increased or decreased equipment costs.
2. Prices computed by the Engineer.
3. Cost analysis of labor, material, equipment, and mark-ups as allowed in 109.05.C.
4. Cost analysis for compensable delays shall be prepared by the Contractor and approved by the Engineer.

Negotiated prices for changes and Extra Work shall be comparable to prices that would have resulted from a competitively bid contract.

If the City negotiates with the Contractor but does not agree on a lump sum or unit price adjustment, the Engineer may direct the Contractor to perform all or part of the revised Work under Force Account or Unilateral Change Order.

C. Force Account.

1. General. Force account procedures shall only be used when necessary, such as when agreement cannot be reached with the Contractor on the price of a new work item, when the extent of work is unknown or is of such character that a price cannot be determined to a reasonable degree of accuracy, or when in the best interest of the City. The reason or reasons for using force account procedures shall be documented. When directed by the Engineer, the Contractor shall submit a cost estimate and written description of the Work, including the planned equipment, materials, labor, and work schedule.

If the Contractor performs any work that it submits for payment as a force account, it must notify the Engineer in writing before beginning the work such that the City may track the materials, labor, and equipment in order to verify the Contractor's quantities. If the Contractor fails to notify the Engineer in writing before beginning force account work, the work performed by the Contractor shall be paid for under the original contract sum. However, the Contractor shall not be entitled to any compensation for force account work if it is later determined that the work was otherwise included in the original contract or determined to be otherwise non-compensable under the Contract. The Engineer will provide documentation stating the reasons that the work is non-compensable under the Contract.

2. Labor. For all labor and for all foremen in direct charge of the specific operations, the Contractor shall receive the rate of wage and fringe benefits currently in effect at the time the work is performed for each and every hour that said labor and foremen are actually engaged in such work, to which may be added an amount equal to 38 percent of the sum thereof. In addition to the above, the Contractor shall itemize the actual cost of Social Security Tax, Worker's Compensation and State and Federal Unemployment Insurance. In lieu of itemizing these 4 items, 22 percent of the sum of wages may be added.

The City will pay, without mark-up, the actual itemized cost of fees and dues paid to labor unions or to business associations when they are based on payroll hours and required by a collective bargaining agreement. The City will not pay for wages or benefits for personnel connected with the Contractor's forces above the classification of foreman that have only general supervisory responsibility for the force account work. (Proration of hours between force and non-force account work also is required.)

The City will pay the prevailing wage and fringe rates that apply to the Project for the classifications required for Extra Work. The Contractor must provide payroll records for pay rates higher than the prevailing wages and establish that the higher than prevailing rates are paid for original Contract Work. The City will pay for foremen and time keepers not covered by prevailing wages not more than the salaried rate they receive when engaged in original Contract Work.

3. Materials. The City will pay Contractor's actual invoice costs, including applicable taxes and actual freight charges, for Engineer-approved materials that the Contractor uses in force account work. The City will pay an additional 15 percent mark-up on these costs. Freight or hauling costs charged to the Contractor and not included in unit prices shall be itemized and supported by invoices. The cost of owned or rented equipment used to haul materials to the Project shall not be part of the materials cost. The Contractor shall submit invoices to support the quantities of materials used, unit prices paid and transportation charges.

If the Contractor uses materials from the Contractor's stock and original receipted invoices for the materials and transportation charges do not exist, the City and the Contractor will agree on a price that represents the actual cost to the Contractor.

4. Equipment.

a. General. The City will pay the Contractor's costs for equipment that the Engineer deems necessary to perform the force account work for the time directed by the Engineer or until the Contractor completes the force account work, whichever happens first. The City will pay the Contractor the established rates given in the Equipment Watch Cost Recovery (formerly Rental Rate Blue Book), by Equipment Watch, a division of Penton Business Media, Inc. for equipment only during the hours that it is operated, except as otherwise allowed elsewhere in the Specifications. The City will pay for non-operating hours at the idle equipment rate as specified in 109.05.C.4.c. Established equipment rates in the Specifications include compensation for overhead and profit except as otherwise specified.

The City will not pay rental for small tools or equipment that has a value of less than $500.00, unless such equipment is shown to be specialized to a specific area of work and not normally included in the Equipment Watch Cost Recovery book. Traffic control devices used in maintaining traffic and owned by the Contractor will be treated as owned equipment. Allowed rates for common traffic control devices and concrete barrier that are not listed in the Equipment Watch Cost Recovery book will be as determined by the City.

For force account work the Contractor may use Engineer-approved equipment in good working condition and providing normal output or production. The Engineer may reject equipment not in good working condition or not properly sized for efficient performance of the force account work. For each piece of equipment used, whether owned or rented, the Contractor shall provide the Engineer with the following information:

(1) Manufacturer's name or trademark

(2) Equipment type

(3) Year of manufacture

(4) Model number

(5) Type of fuel used

(6) Horsepower rating

(7) Attachments required, together with their size or capacity

(8) All further information necessary to determine the proper rate

(9) Dates, daily hours, total hours of actual operation and idle time

(10) Equipment Watch Cost Recovery rate with reference or category

(11) Quantity

(12) Applicable Equipment Watch Cost Recovery hourly operating cost

(13) Invoices for all rental equipment

b. Hourly Owned Equipment Rates. For any machinery or special equipment other than small tools which it may be deemed necessary or desirable to use for the force account work, the Contractor shall receive payment for such equipment actually engaged in such work (hourly, daily, weekly or monthly).

For all machinery or special equipment already employed on the Project site at the time of the force account work, the Equipment Watch Cost Recovery book shall apply. The monthly rate will be divided by 176 to arrive at the hourly rate. The Contractor will be compensated at that rate for the working hours, which includes only those hours the equipment is actually in operation performing force account work. Base rate for the machine and attachments represent the major cost of equipment ownership, such as depreciation, interest, taxes, insurance, storage, and major repairs. The hourly operating rate represents the major costs of equipment operation, such as fuel and oil lubrication, field repairs, tires, expendable parts, and supplies.

Compensation for equipment normally used on a 24 hours per day basis will not exceed the monthly rate plus adjustments and operating costs. The rate adjustment factor assigned to any attachment will be the yearly factor as determined for the base equipment.

c. Hourly Idle Equipment Rate. For equipment that is in operational condition, on site, and necessary for force account work, but is idle, the City will pay an hourly idle equipment rate. If rented equipment necessary for force account work is idle and with the Engineer's approval, the City will pay the Contractor for all equipment that was idled. The hourly rate of compensation for any idle equipment will be the monthly rental rate times a factor of 0.50 divided by 176 hours per month with no operating costs added.

The City will not pay idle equipment costs for more than eight hours in a 24-hour day or forty hours in a week. The City will not pay for inoperable equipment. Compensation for idle equipment will stop at the completion of the force account work or at the end of the suspension of work.

d. Rented Equipment. If the Contractor rents or leases equipment from a third party exclusively for force account work, the City will pay the actual invoiced amount. The actual invoiced rates must be reasonably in line with the Equipment Watch Cost Recovery book and approved by the Engineer. The City will pay a 15 percent mark-up for overhead and profit for all rented equipment costs supported by the actual invoices. Equipment Watch Cost Recovery hourly operating cost will be added to the marked up actual invoiced rates only for the time the rented equipment was used on the Force Account work.

If the Contractor uses rented equipment currently on the Project for original Contract Work to perform force account Work, then the hourly equipment rate is determined using methods described in 109.05.C.4.b.

The City will not compensate for rental rates that exceed the Equipment Watch Cost Recovery rates unless approved in advance of the work by the Engineer.

5. Foreman's Transportation. The City will pay a flat rate of $4.50 for every hour the foreman's truck is on the force account work. This rate includes equipment cost, fuel and lubricants, overhead, and profit.

6. Subcontract Work. For Work performed by an approved subcontractor, the City will pay the approved subcontractor invoice plus 5 percent mark-up for administrative costs. The administrative cost for subcontract work shall not exceed $5,000.00. No additional mark-up is allowed for work of a subsubcontractor or trucking services employed by a subcontractor.

7. Payment for Force Account Work. The compensation to the Contractor as provided in 109.05.C shall constitute payment in full for Extra Work done on a force account basis, including administration, superintendence, overhead, use of tools and equipment for which no rental is allowed, profit, taxes other than sales tax, premium on insurance, and any other expense incidental to performing the force account work. Sales tax will not be allowed on any item for which tax exemption may be obtained.

8. Force Account Records. The Contractor's representative and the Engineer's or City's representative shall compare records daily of the extra work done as ordered on a force account basis. Daily Force Account Records shall be signed by both the City and the Contractor daily. In the event the Contractor declines to sign the Daily Force Account Record, the City's records shall govern. Any resulting dispute must be pursued in accordance with 104.03.

City and Contractor personnel will document the labor and equipment used on the Force Account work on a Daily Force Account Record. At the end of each Work Day, City and Contractor personnel will compare and sign the Daily Force Account Record. The City will make no Force Account payment before the Contractor submits an itemized statement of the costs for that work. The Engineer will examine and, if found to be acceptable, approve all rates and costs submitted by the Contractor.

Final payment will not be made for Work performed on a force account basis until the Contractor has furnished the Engineer with itemized statements of the costs of such force account work detailed as follows:

a. Name, classification, date, daily hours, total hours, rate, and extension for each laborer and supervisor.

b. Designation, dates, daily hours, total hours, rental rate, and extension for each unit of machinery and equipment.

c. Quantities of materials, prices, and extensions.

d. Transportation of materials.

Statements shall be accompanied and supported by proper invoices for all materials used and transportation charges, and rented equipment performing work on force account operations. However, if materials used on the force account work are not specifically purchased for such work but are produced by the Contractor or taken from the Contractor's stock, then in lieu of the invoices the Contractor shall furnish an affidavit certifying that such materials were produced by or taken from the Contractor's stock, that the quantity claimed was actually used, and that the price

and transportation claimed represent the actual cost to the Contractor. Statements shall be filed not later than thirty days following the date the work was actually performed. Failure to submit acceptably completed statements within thirty days of the date the work was performed will result in an administrative fee of $100 per Calendar Day for each delinquent force account statement.

9. Professional and Specialized Work. The following work, when performed by a firm hired by the contractor, is paid at the reasonable and fair market invoiced cost plus 8% on the first $10,000 of work and 5% for work in excess of $10,000:

a. Surveying.

b. Engineering design.

c. Specialized work that is not normally part of a Department Contract and is not normally subject to prevailing wage.

d. Other professional or specialized work not contemplated at the time of Bid.

D. Delay Costs.

1. General. If the City agrees that it is responsible for a delay as defined by 108.06, the City will pay for the costs specified in 109.05.D, unless these costs have been previously paid. Such payment constitutes full compensation for any and all delay costs.

Submit an itemized statement of applicable costs in the time period specified in 109.05.C.8 and that includes the content specified in 109.05.C.8 for the applicable items in this subsection and the following:

a. Proof of cost of Superintendent, or other project staff salaries, wages, and payroll taxes and insurance.

b. Proof of cost of office rent, utilities, land rent, and office supplies.

c. Proof of escalated cost for labor and material.

d. Proof of material storage costs.

2. Allowable Delay Costs.

a. Extended Labor. The City will pay labor costs during delays as specified in 109.05.C.2 for all non-salaried personnel remaining on the Project as required under collective bargaining agreements or for other Engineer-approved reasons.

b. Escalated Labor. To receive payment for escalated labor costs, demonstrate that the delay forced the Work to be performed during a period when labor costs were higher than planned at the time of the Proposal. The City will pay wages and fringes with a 20 percent mark-up to cover administrative costs.

c. Idle Equipment or Equipment Demobilization. The City will pay the Contractor according to 109.05.C.4.c for idle equipment, other than small tools, that must remain on the Project during the delay period. With prior approval, the City will pay the Contractor's transportation costs to remove and return equipment not required on the Project during the delay period. No other equipment costs shall be recoverable as a result of delay.

d. Material Escalation or Material Storage. The City will pay the Contractor for increased material costs or material storage costs due to the delay. Obtain the Engineer's approval before storing materials due to a delay. Payment will be based upon the accepted quantity of work performed during the period for which escalated costs have been approved. The City will pay increased material costs with an 8 percent mark-up to cover administrative costs and any material waste inherent to the Work.

e. Overhead and Profit. The City will pay a 15 percent mark-up on all direct costs as all-inclusive compensation of all other Contractor costs, including but not limited to, (i) home office overhead, unabsorbed home office overhead, extended home office overhead, and all other overhead costs for which payment is not provided for in 109.05.D.2 and (ii) profit.

E. Unrecoverable Costs. The Contractor shall not be entitled to additional compensation for any costs not specifically allowed or provided for in 109.05, including, but not limited to, the following:

1. Loss of anticipated profit.
2. Consequential damages, including loss of bonding capacity, loss of bidding opportunities, insolvency, and the effects of force account work on other projects, or business interruption.
3. Impact, Disruption, Loss of Efficiency, Loss of Productivity.
4. Indirect costs.
5. Attorneys' fees, claim preparation expenses, and the costs of litigation.

F. Damages for Termination for Convenience. If the Contract is terminated in accordance with 108.08.B, Termination for Convenience, the City will compensate the Contractor the following costs:

1. Payment for Completed Work. All completed items of Work as of the date of termination will be paid for at the Contract bid price. Payment for partially completed Work at the time of termination will be based upon actual costs incurred up to the date of termination and payment will be made either at agreed prices or by force account methods for extra work change order. The reasonable costs of the termination of convenience, may include accounting, clerical and other expenses, reasonable storage, transportation as set forth herein and the cost of demobilization which cannot exceed the price bid item and other reasonable and verifiable costs incurred in connection with the protection or disposition of materials obtained for this Project

2. Materials. Payment for materials included in the material inventory will be made at actual cost delivered to the project or the City designated storage site, including transportation charges to which 15 percent for all overhead and profit mark-up will be added but shall not exceed the unit bid price for the referenced number involved. If the material is not turned over to the City, the City will pay the Contractor a restocking charges or actual disposal costs supported by paid invoices and an additional 5 percent mark-up on the overhead and profit. In addition hauling costs, if not included in the restocking charges for returned material and for material delivered to the City, are compensable.

3. Idle Equipment. Claims for idle equipment time, if any, following termination of the Contract, are limited to a maximum of thirty days and may not include any operating expenses. In the case of rented or leased equipment, the Contractor shall recover the lesser of the actual rental costs or fair market rental costs as established in 109.05.C and the amount shall not exceed thirty days rental.

4. Overhead and Profit. The mark-up for overhead and profit will comply with 109.05.C, except as provided in 109.05.F. In no event, however, shall consequential damages, loss of overhead, loss of overhead contribution or absorption of any kind, or loss of anticipated profits on Work that was not performed, be compensable or considered as part of any settlement.

109.06 Directed Acceleration. The Contractor shall always have the obligation to complete the Work in the time frames set forth in the Contract, provided, however, the Engineer, in writing, may order the Contractor, or may approve the Contractor's written request, to accelerate the Work to avoid or mitigate delay or associated costs or to complete the Project earlier than the Contract Completion Date. For purposes of this Section, lack of express written direction or approval by the Engineer shall never be construed as consent or direction to accelerate the Work.

In the event of an Engineer ordered or approved acceleration, the Engineer and the Contractor shall negotiate and agree on acceleration costs in advance of any acceleration work being started. To the extent, however, that the direction or approval to accelerate was due to delay caused by the fault or responsibility of the Contractor, the Contractor shall not be entitled to any additional time or costs associated with the acceleration. To the extent that the acceleration was directed for the benefit of the City or for a reason not the fault or responsibility of the Contractor, the Contractor will be entitled to a time or cost adjustment as provided by 108.06 and 109.05.

109.07 Estimates (Partial Payments). If satisfactory progress is being made, the Contractor will receive monthly payments based on the value of the Work completed and the materials in place and for materials delivered as specified in 109.10 as determined by the Engineer. The monthly payment is an approximation only, and all partial estimates and payments shall be subject to correction in the Final Estimate and payment. Pay estimates must be signed by the Contractor and approved by the Engineer.

Payment for Work and materials shall not, in any way, prevent later rejection when defective work or material is discovered, or constitute acceptance under 109.11. No estimate or payment shall be construed as acceptance of unacceptable work or non-conforming materials. The City will not pay the adjusted Final Estimate until the Contractor remedies all unacceptable work, defective work, and accepted work damaged by the Contractor's operations.

Before the second partial pay estimate is processed and for each subsequent partial estimate thereafter, the Contractor shall submit a notarized affidavit confirming that all bills for materials and for subcontracted Work represented by the previous partial payment have been paid. The City will not pay an estimate until the Contractor certifies to the Engineer that the Work for which payment is being made was performed in accordance with the Contract Documents. Certification will be made on forms provided by the City.

Should any unacceptable Work, non-conforming material, or acceptable Work that has been damaged by the Contractor's operations be discovered prior to final acceptance thereof or should a reasonable doubt arise prior to final acceptance as to the integrity of any part of the completed Work, the estimate and payment for such defective or questioned Work shall not be allowed until the defect has been remedied and cause for doubt removed, by and at the expense of the Contractor.

Partial payments may, at any time, be withheld, if in the opinion of the Engineer, any Work will not be completed in accordance with the Contract Documents.

109.08 Project Contingency. Project Contingency is identified in the Proposal. This amount shall be included in the Contract Sum and shall be included in the coverage of the Proposal Guaranty. During the Contract, this Pay Item shall be utilized by the City as a resource for funding necessary changes in the Work. Project Contingency shall not, however, be considered a sum to which the Contractor has any entitlement, except as portions of it are assigned for payment by Change Order, and as progress is made by the Contractor upon the Work under such Change Order.

Upon completion of the Work under this Contract, any portion of the Project Contingency which has not been assigned for payment by Change Order shall be deducted by the final Contract Modification. Thereafter, such deducted amount may be deleted from the Contractor Bond, warranty, guarantee, and other applicable coverage.

109.09 Retainage. Ten percent of the Estimates may be retained by the City until fifty percent of the Work has been satisfactorily completed. When more than fifty percent of the Work has been satisfactorily completed, the amount retained may be reduced to five percent for all Work satisfactorily completed to the date of the estimate. When more than ninety percent of the Work has been completed and approved for payment, the amount retained may be reduced to 2.5% of the satisfactorily completed Work. The Engineer may also, at any time, increase retainage by any amount needed to protect the City's interests with respect to any incomplete, defective or unsatisfactory Work; costs or damages incurred by the City that are subject to the Contractor's obligations under this Contract; or backcharges that the City may assess against the Contractor.

The Contractor is hereby put on notice that the City will neither deposit retainage in an escrow account, nor pay interest on such retainage.

109.10 Payment for Material on Hand. The City may pay, up to 75 percent of the applicable contract item, for the invoiced cost of the delivered and approved materials before they are incorporated into the Work, when delivered on the Project or stored in acceptable storage places. Delivered cost shall be evidenced by supplier's or manufacturer's invoice bearing the statement that all previous invoices have been paid.

The Contractor shall make application for payment for materials on hand or stored on a form provided by the City. Information will be required as to the cost of the materials, when such materials will be incorporated in the Work and such other information that will be considered for approval of such payment. Consideration will be given only as to materials for major items of the Contract.

No partial payment will be made on living or perishable plant materials.

109.11 Final Inspection and Acceptance.

A. Partial Acceptance. Upon completion of a portion of the Work, the Contractor may request acceptance of the completed portion of the Work.

1. An inspection may be performed on a completed portion of the project roadway section provided:
   a. All safety items are in place, including permanent pavement markings.
   b. Traffic is in its final pattern.
   c. The completed portion of the project Work constitutes a completed geographic section of the project or a direction of traffic on a divided highway.
   d. The request is in accordance with all other contract provisions.
2. An inspection may be performed on a completed bridge provided:
   a. All work on the bridge and approaches is complete, including all safety items and permanent pavement markings.
   b. Traffic is in its final pattern.
   c. The Contractor will not return to the bridge for any further work except as allowed for by item d.
   d. Painting of structural steel is either completed or scheduled to be performed.
   e. The request is in accordance with all other contract provisions.
3. An inspection may be performed on completed portions of the Work otherwise not listed above given:
   a. The Work completed is of substantial completion as recognized by the Engineer.
   b. Work is fully functioning as intended in the project.
   c. If necessary, outside agencies have accepted the Work.
   d. The request is in accordance with all other contract provisions.

The Engineer shall grant written partial acceptance for the portion of the Work if accepted. The Engineer will have exclusive rights to reject the Contractor's request for the convenience of administering the contract. The written partial acceptance will identify what portion of the Work is being accepted, the date of acceptance, and the warranty provisions initiated by the partial acceptance.

Partial acceptance shall relieve the Contractor of maintenance responsibility for the accepted portion of the Work. Partial acceptance shall not relieve the Contractor of the responsibility to correct defective Work or repair damage caused by the Contractor, nor shall it waive the right to any other remedy to which the City is entitled by law or in equity.

B. Final Inspection. The Final Inspection shall be a limited visual review of the Work and shall only serve as the City's verification that the Work appears substantially complete. Final Inspection does not waive any available rights or remedies of the City, nor divest the Contractor of any responsibility for compliance with the Contract Documents or liability for damages.

When the Contractor completes all or portions of the Work to be accepted by the City, a request by the Contractor for a Final Inspection shall be made. If the Engineer agrees the Work is complete, then within ten business days the Inspector will inspect the Work and categorize it as one of the following:

1. Unacceptable or not complete.
2. Substantially complete with punch list items found by the Inspector.
3. Substantially complete.

If the Inspector finds the Work substantially complete or substantially complete with punch list items, then the Contractor's maintenance responsibilities end on the day of the Final Inspection, except for any maintenance related to unfinished punch list items. This shall not relieve the Contractor of responsibility to correct defective Work or repair damage caused by the Contractor or waive any other remedy to which the City is entitled under the Contract, applicable law, in equity, or otherwise. The Inspector will issue a Final Inspection Report that will document the findings of the inspection and start any guarantee and warranty period(s).

C. Punch List. As provided in this Section, the Engineer will issue to the Contractor a written punch list of work required as a condition of acceptance. For projects involving multiple public agencies, the Engineer will receive and compile punch lists from all agencies that have authority to provide one prior to issuing the Department's punch list. The Engineer's punch list will stipulate a reasonable time to complete the required work unless the Contractor can demonstrate to the Engineer that completion of the punch list work within the Engineer's time frame is unreasonable. An excusable, non-compensable time extension shall be executed to encompass the punch list's reasonable time to establish new Interim and Final Completion Date(s) and 108.07 requirements shall be administered respectively. Use of Interim Completion Dates for the punch list work shall be

the discretion of the Engineer; necessary to separate weather sensitive work. During the negotiated time frame both the Engineer and the Contractor shall anticipate weather per Table 108.06-1.

Notify the Engineer in writing when all of the punch list items are complete. No further extension shall be provided for Work that is not remedied to the satisfaction of the Engineer.

D. Finalization. The Contractor will receive the Engineer's list of final quantities within forty five Calendar Days from the date that the Work is determined to be substantially complete by the Inspector. The Contractor shall accept the final quantities as determined by the Engineer or provide a written notice indicating the reason for disagreement within thirty Calendar Days of receiving the Engineer's list of final quantities. The prescribed thirty Calendar Day period can be modified by mutual agreement of the Contractor and the Engineer. If no notice of disagreement is received, then the final estimate shall be based on the Engineer's list of final quantities.

Within sixty Calendar Days from receipt of the Engineer's list of final quantities, the Contractor shall supply Final Project Documents for Project closeout, to include, but not be limited to:

1. Material certificates
2. Payrolls
3. Wage affidavits
4. DBE/MBE/WBE affidavits, if applicable
5. As-built drawings as required
6. Warranties
7. O&M Manuals
8. Lien Waivers
9. Final Force Account Statement(s)
10. Surety Consent for Final Payment
11. Spare Parts List
12. Certificate of Completion
13. Bond Rider (Check with the bond form)
14. Affidavit of Final Payment

Failure to submit these acceptably completed documents will result in an administrative fee of $100.00 per Calendar Day deducted from the Final Pay Estimate for every day that any of the required documents remain delinquent, starting thirty Calendar Days after receipt of written notification from the Engineer of a document deficiency.

E. Final Acceptance/Project Closeout Process. After the Final Inspection and the issuance of the Punch List, the Contractor must complete the items on the Punch List in the stipulated time frame. After completing the items on the punch list, the Contractor shall notify the Engineer to confirm that the items have been completed. When the work noted on the Punch List has been confirmed to be complete and accepted, the Engineer will issue a Notice of Final Acceptance.

Final Acceptance of the Work does not waive any available rights or remedies of the City under the Contract, applicable law, in equity, or otherwise, and shall not discharge the Contractor from any obligations it has under the Contract, including, but not limited to: unsettled liens and claims against the City; faulty, defective, or nonconforming work discovered or appearing after Final Acceptance; failure of the Work to comply with the requirements of the Contract Documents; the terms of any warranties or guarantees contained in or required by the Contract Documents; any indemnification rights including damages or costs incurred by the City resulting in claims or lawsuits brought against the City based on actions on the part of the Contractor, its subcontractors, sub-subcontractors, suppliers, or any of their employees, representatives or agents; fraud or bad faith committed by the Contractor or any subcontractor or supplier during performance of Work, but discovered by the City after Final Payment; and the City's audit and adjustment rights under the Contract.

F. Final Estimate. Final payment to the Contractor is based on:

1. The agreed final quantities or as determined by the Engineer;
2. Finding of Final Acceptance by the Engineer;
3. Receipt of acceptable Final Project Documents; and
4. Contractor certification that the Work was performed in accordance with the Contract Documents.

As soon as practical after the Final Acceptance of the Work by the City and after approval of the final Change Order, or the final Contract Modification if the final Contract Amount exceeds the amount authorized by City Council, there shall be issued a final estimate for payment based upon the actual quantities of completed and accepted Work performed under the Contract. Compensation will not be made for any Work that was not authorized.

Final Estimates shall be approved by the City, after which the City shall pay the entire sum found to be due, after deducting all previous payments under 109.07. All prior estimates are subject to correction in the Final Estimate.

G. Completion of Contract and Continuation of Contractor's Responsibility. The Engineer will issue a letter confirming completion of the Contract, noting any exception as provided in Items 659 and 661 and any guarantee or warranty.

The Contract is complete, except for items covered by any required bonds, when the Contractor receives final payment.

Neither Substantial Completion, Partial Acceptance, Final Acceptance nor Completion of the Contract relieves the Contractor of any responsibilities to properly perform or correct the Work or to repair damage or waives any remedies to which the City is entitled under the Contract, at law, in equity, or otherwise.

109.12 Release of Liability. No person(s) or corporation(s) other than the signer of this Contract as Contractor, has any interest hereunder and no claim shall be made or be valid, and neither the City, nor any official or agent thereof, shall be liable for or be held to pay any money, except as provided in the Contract. The acceptance by the Contractor of final payment shall operate as and shall be a release to the City, and every officer and agent thereof, from all claims and liability to the Contractor for anything done or furnished for, or relating to the Work, or for any act or neglect of the City, or of any person relating to or affecting the Work.

109.13 Guarantee/Warranties. Unless otherwise noted in the Contract Documents, the guarantee period begins upon Final Acceptance of the Work by the City. The guarantee period extends for one year from the date of Final Acceptance.

Under the Contractor's guarantee, the Contractor warrants to the City that materials and equipment furnished under the Contract are of good quality and new unless otherwise required or permitted by the Contract Documents, that the Work is free from defects not inherent in the quality required or permitted; that the Work conforms to all requirements of the Contract Documents; that the Work is complete and fully functional; and that any failure to conform to these requirements or the occurrence of any defects or failures in the Work shall be remedied by the Contractor promptly and at no cost to the City.

In addition to the Contractor's guarantee and without in any way diminishing or changing it, the Contract Documents may also specify other express Contractor warranties or subcontractor, manufacturer or supplier warranties that apply during, or after, the Contractor's guarantee period. Notwithstanding the existence of other warranties, the Contractor shall remain as the responsible party to the City under the Contractor's guarantee for purposes of the City exercising its rights under this Section during the one-year guarantee period.

The guarantee provisions do not relieve the Contractor from completing the Work in accordance with the Contract and do not diminish any rights or remedies the City may have under the Contract, applicable law, in equity, or otherwise.

At any time during the guarantee period, the City may notify the Contractor that certain repairs or other actions are necessary. Within ten days after being so notified, the Contractor shall make such repairs or take such other actions as are declared necessary to restore the Work to a good and serviceable condition consistent with the requirements of the Contract Documents. In the event that the Contractor fails to comply with the order to repair or take other actions, such repairs may be made or other actions undertaken by the City and the Contractor agrees that it shall reimburse the City for any such expenses it incurs within ten days following the receipt of a statement rendered to the Contractor by the City for such expenses. Specifications for the Work performed under this Contract shall govern in the making of repairs or taking other action pursuant to this Section.

Upon the expiration of the one-year guarantee period, the Contractor shall take all steps necessary to transfer to the City all remaining rights and obligations that may exist under any other warranties from the Contractor, subcontractors, manufacturers or suppliers and shall continue to assist the City, as needed, to enforce such warranties.

If the cost of providing security to the City of Columbus for the one-year guarantee period is prohibitive, the Contractor may, with approval from the Director, make an assignment of bonds or other form of acceptable security to the City in the amount of 5 percent of the contract cost for the duration of the guarantee period.

109.14 Backcharges. To the extent the City has the right to back charge the Contractor pursuant to the Contract, the City, at its option, may take one or more of the following actions: (i) require the Contractor to make payment to the City within ten days of the Contractor's receipt of the invoice; (ii) deduct the back charge from the next and subsequent pay estimates until the full amount of the back charge has been satisfied; or (iii) deduct the back charge from Retainage. The City's right to back charge is in addition to any or all other rights and remedies provided in the Contract, at law, in equity, or otherwise.

109.15 Right to Set-Off. The City shall have all of its contractual, common law, equitable, and statutory rights of set-off. These rights shall include, but are not limited to, the City's option to withhold for the purposes of set-off (i) any monies due or that may become due to the Contractor under this Contract; (ii) any monies due or owing under any other contract with the City Department that holds or funds this Contract; or (iii) any monies due or owing the Contractor under any other contract with the City for tax delinquencies, fee delinquencies, or monetary penalties relative thereto. The City shall exercise its set-off rights pursuant to audit by the City Auditor, or its representative.

200 EARTHWORK

ITEM 201 CLEARING AND GRUBBING

201.01 Description
201.02 General
201.03 Clearing and Grubbing
201.04 Scalping
201.05 Method of Measurement
201.06 Basis of Payment

201.01 Description. This work consists of clearing, grubbing, scalping, removing trees and stumps, and removing all vegetation and construction debris from the limits shown on the plans, except such objects that are to remain or are to be removed according to other items of work.

Use removed or excavated materials in the work when the material conforms to the specifications; if not then dispose of the material according to 105.16 and 105.19.

201.02 General. Provide temporary sediment and erosion controls according to the requirements of Item 207. Include such work in Item 201 unless specific pay items for temporary sediment and erosion controls are listed on the plans or in the proposal.

Repair damage to trees or shrubs according to the directions of the City Forester.

A. Remove or save all trees, shrubs, and plants as designated on the plans. Preserve all vegetation and objects not designated for removal.

B. In order to retard and prevent the spread of destructive insects, limit the movement of regulated articles according to Ohio Administrative Code 901:5. Observe requirements for handling and transporting of regulated articles in quarantined areas as defined by the Ohio Department of Agriculture.

Follow all other federal and state destructive insect quarantines.

C. Restrictions on when the Contractor may perform the clearing and grubbing work are located in other parts of the Contract Documents.

201.03 Clearing and Grubbing. Clear and grub all trees and stumps marked for removal and all surface objects, brush, roots, and other protruding obstructions not designated to remain, except for special treatments listed below:

A. In locations to be seeded, remove stumps at least 6 inches below ground surface.

B. In unseeded areas to be rounded at the top of backslopes, cut the stumps flush with or below the surface of the final slope line.

C. The Contractor may leave undisturbed stumps and roots, and nonperishable solid objects 6 inches above the existing ground surface in the plan embankment construction locations when both of the following conditions are true:

1. The embankment height is greater than 9 feet as measured vertically from the existing ground surface to the proposed ground surface, and
2. The slope of the existing ground is 8:1 or flatter.

D. In locations outside of the construction limits of the cut and embankment areas not to be seeded, the Contractor may leave sound stumps 24 inches above the existing ground surface.

Except in areas to be excavated, backfill stump holes and other holes created by removing obstructions with Item 203 Embankment Material. Place and compact according to Item 203.

Remove low hanging, unsound, or unsightly branches on trees or shrubs designated to remain. Trim branches of trees extending over the roadbed to provide a clear height of 20 feet above the roadbed surface.

Dispose of debris contaminated with garbage, solid waste, or hazardous waste or material according to other contract items.

201.04 Scalping. Scalping includes removing surface material such as roots, sod, grass, residue of agricultural crops, sawdust, and decayed vegetable matter. The depth of scalping does not include topsoil or other material below the scalping operation. The Engineer will not require areas to be scalped in the plan embankment construction locations when both of the following conditions are true:

1. The embankment height is greater than 9 feet as measured vertically from the existing ground surface to the proposed ground surface, and
2. The slope of the existing ground is 8:1 or flatter.

Scalp all other areas where excavation or embankment is required.

201.05 Method of Measurement. The City will measure by one of the following methods:

If Clearing and Grubbing is specified in the Contract, the City will not measure the area cleared and grubbed.

If Item 201 Tree Removed or Item 201 Stump Removed is specified in the Contract, the City will measure trees and stumps designated for removal according to the following table.

TABLE 201.05-1

Tree or Stump Diameter	Pay Item Designation
Over 12 inches to 24 inches	18-inch size
Over 24 inches to 36 inches	30-inch size
Over 36 inches to 60 inches	48-inch size
Over 60 inches	60-inch size

The City will measure the diameter of trees at a height of 54 inches above the ground. Trees 12 inches and less in diameter are classified as brush. The City will measure stumps by taking the average diameter at the cutoff.

201.06 Basis of Payment. If Item 201 Clearing and Grubbing is specified in the Contract, the City will pay for all work described, including backfilling holes, scalping, and removing all trees and stumps, at the lump sum price bid. If Item 201 Tree Removed or Item 201 Stump Removed is specified in the Contract, the City will consider the remaining work described incidental and will not pay for performing this work directly.

The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
201	Lump Sum	Clearing and Grubbing
201	Each	Tree Removed, ___ Size
201	Each	Stump Removed, ___ Size

ITEM 202 REMOVAL OF STRUCTURES AND OBSTRUCTIONS

202.01 Description
202.02 General Construction Requirements
202.03 Structures Removed
202.04 Pipe Removal
202.041 Pipe Filled In Place
202.05 Pavement, Walks, Curbs, Steps, Gutters, or Traffic Dividers Removed
202.06 Buildings Demolished
202.07 Septic Tanks and Privy Vaults Removed
202.08 Underground Storage Tanks Removed
202.09 Guardrail and Fence Removed
202.10 Manhole, Catch Basin, and Inlet Removed
202.11 Manhole, Catch Basin, and Inlet Abandoned
202.12 Method of Measurement
202.13 Basis of Payment

202.01 Description. This work consists of removing, entirely or in part, and disposing of all buildings, fences, guardrails, structures, old pavements, abandoned pipelines, storage tanks, septic tanks, privy vaults, and other obstructions not designated or permitted to remain, except for utilities and obstructions to be removed and disposed of under other items in the Contract. This work also consists of backfilling the resulting trenches, holes, and pits, and salvaging designated materials.

When specific pay items for removal of structures and obstructions are not listed in the Contract Documents, perform this work under Item 203.

202.02 General Construction Requirements. Raze, remove, and dispose of all buildings and foundations, Structures, fences, guardrails, old pavements, abandoned pipe lines, storage tanks, septic tanks, privy vaults, and other obstructions within the Right-of-Way, except for utilities and those items where other provisions have been made for removal. Remove and store, at the specified locations within the Project limits, or reuse all designated salvageable materials.

The City will take ownership of all salvageable items specified for storage. Reuse all salvageable items specified for reuse on the project. When the Contract Documents do not indicate for storage or for reuse, take ownership of the material.

Use removed or excavated materials in the Work when the material conforms to the specifications; if not, then dispose of the material according to 105.16 and 105.19.

Do not remove any item in use by traffic until after making arrangements to accommodate traffic.

When backfilling is required, backfill the resulting cavities, voids, or trenches with either Item 203 Embankment Material or Item 603 Structural Backfill Type 1 or 2. Use Item 603 Structural Backfill when the removed item is under the proposed pavement or paved shoulder and when the site limits the use of compaction equipment larger than an 8-ton roller; otherwise the Contractor may use Item 203 Embankment Material. Place and compact the embankment or Item 603 Structural Backfill according to Item 203.

For backfilled areas outside the plan construction limits, provide a final grade that presents a neat, well-drained appearance that conforms to the final topography and prevents water from draining onto adjacent properties.

202.03 Structures Removed. Remove bridges, culverts, and other structures indicated for removal in the Contract Documents. If within a stream, remove the substructures of existing structures, including piling, down to the proposed stream bottom. For those parts outside the stream, remove substructures to a minimum of 1 foot below proposed ground surface. Remove, as necessary, those portions of existing structures that lie entirely or partially within the limits for a new structure to accommodate the construction of the proposed structure.

Where alteration of an existing structure requires removal of portions of the structure, remove those portions with sufficient care as to avoid damage to the remaining portion of the structure. In case of damage to the existing structure, repair or replace the structure at no expense to the City. Remove any existing welded form hangers, welded attachments two inches or longer measured parallel to the long axis of the top flange of steel beams or girders, and welded attachments that interfere with the placement of welded shear connectors.

If removing a bridge or portion of a bridge with an asphalt wearing course, remove the wearing course separately before removing the bridge or portion of the bridge.

Backfill the cavity created by the removal item according to 202.02, except when the cavity lies within the limits of subsequent excavation or other work.

202.04 Pipe Removal. Remove and reuse, store, or dispose of pipe, or culvert, including headwalls, as specified in the Contract Documents.

If removing an existing concrete waterline pipe that was constructed before 1980, it may be an asbestos pipe. Test the pipe by using an Asbestos Hazard Evaluation Specialist certified by the Ohio Department of Health to determine if it is an asbestos pipe. If it is determined that the pipe is asbestos containing and is to be removed, an Ohio licensed Asbestos Hazard Abatement Contractor must perform the work. Dispose of all asbestos containing pipe at a solid waste or Construction and Demolition Debris facility that is licensed by the Local Health Department and permitted by the OEPA for the acceptance of asbestos containing material.

Seal openings left in walls of manholes or catch basins that are to remain in place, and remove and dispose of pipe headwalls.

If an adjacent existing pipe is encountered during removal operations and the pipe is inactive or is to be abandoned, plug or seal the remaining ends of the pipe before proceeding with backfilling operations. Perform plugging by using approved precast stoppers. Perform sealing by using masonry bulkheads.

Remove a sufficient section of the pipe to allow the Engineer to determine the quality of the pipe and the possibility of its removal without damage to pipe specified for reuse or storage. If the Engineer determines the pipe is salvageable, carefully remove the remainder of the pipe to avoid breaking or damaging the pipe. Transport and store the removed pipe, as necessary before relaying. Replace sections of pipe lost or damaged by negligence or by use of improper methods at no additional cost to the City. Clean all pipe before reusing. Remove salvageable pipe under Item 202 Pipe Removed for Reuse or Storage.

If the Engineer determines the pipe is unusable, take ownership of the pipe, and dispose of it according to 202.02. Remove unusable pipe under Item 202 Pipe Removed.

Before backfilling the trench, excavate the caved material, as necessary.

Backfill trenches resulting from the removal of pipe according to 202.02, except when the trench lies within the limits of subsequent excavation or other work.

202.041 Pipe Filled In Place. This work consists of leaving specified lengths in place and constructing masonry bulkheads or placing precast stoppers and filling the pipe's internal void. The fill material shall be controlled density fill mix as specified on the plans unless other materials are specified.

202.05 Pavement, Walks, Curbs, Steps, Gutters, or Traffic Dividers Removed. As designated, remove and dispose of the existing wearing course, concrete base course, concrete pavement, asphalt wearing course on brick or concrete base, concrete walks, concrete steps, concrete gutters, stone or concrete curbs, and concrete traffic dividers. If removing only a portion of an existing pavement, walk, step, gutter, curb, or traffic divider, saw or otherwise cut a neat joint at the removal limit if it does not occur at an existing joint. Include the cost of sawing or cutting under Item 202.

If Item 202 Pavement Removed is specified in the Contract, remove all asphalt, concrete, or brick from the surface to the bottom of the pavement courses as shown on the plans. If Item 202 Base Removed is specified in the Contract, remove the specific layer as shown on the plans. If Item 202 Wearing Course Removed is specified in the Contract, remove all asphalt from the surface to the top of the concrete or brick or remove the specific layer or layers shown on the plans.

Backfill the cavity created by the removal item according to 202.02, except when the cavity lies within the limits of subsequent excavation or other work.

In areas where curb and gutter is to be replaced, ensure that the existing underdrains are not damaged when removing curb and gutter concrete.

202.06 Buildings Demolished. Do not disturb buildings and appurtenances designated for demolition until the Engineer provides a Notice of Possession and Approval to Proceed. Immediately after receiving approval, schedule and perform the demolition under the Engineer's direction in order to accommodate utility rearrangements and clearance of structures. Whether the building is located partially or totally on temporary or permanent Right-of-Way perform the demolition the same.

The Contractor may use buildings located partially on and off the permanent Right-of-Way for storage, office, living quarters, or other purposes. The agreement shall allow such use during the period of the Contract and save the City harmless from any claims whatsoever by reason of such use.

Remove foundations; floors; floor slabs; and basement, pit, well, and cistern walls to a minimum of 1 foot below the grade of the surrounding area.

Completely remove all tanks and clear basements of all materials, debris, appliances, wood or metal partitions, and wood floors so only masonry walls and concrete basement floors remain. Break up and remove all floor slabs under which a pit, well, cistern, or tank exists. Break up basement floors to be left in place, and seal remaining drains with masonry or with precast clay or concrete stoppers.

Take ownership of all materials, except those belonging to a public or private utility. Notify the owners of water, electric, or gas meters when the meters are ready for removal. Disconnect all utilities according to local requirements.

After completing demolition work and obtaining the Engineer's approval, immediately backfill the cavity created by the removal item according to 202.02, except when the cavity lies within the limits of subsequent excavation or other work.

202.07 Septic Tanks and Privy Vaults Removed. When abandoning a sewage treatment system (STS), obtain a permit and inspection from Columbus Public Heath, except in the event that the residence or place of business served by the STS is connecting to a sanitary sewer. Columbus Public Health must be notified within 30 days of the abandonment and should be provided with the following information:

1. Owner and location of the abandoned STS
2. The date of the abandonment
3. The name of the registered septage hauler that removed the contents of the tank
4. The name of the person or registered installer that performed the STS abandonment
5. A description of how all components of the STS were abandoned

In the event that the residence or place of business served by the STS is connecting to a sanitary sewer, the Department of Public Utilities will supply this information to Columbus Public Health, and a health department inspection and permit are not required.

Empty all septic tanks and privy vaults. Dispose of the removed contents in a manner that conforms to the requirements of the State and Local Boards of Health or other authorities having jurisdiction and in accordance with the Ohio Administrative Code 3701-29.

Completely remove and dispose of septic tanks and privy vaults located above the subgrade or finished ground surface. For septic tanks and privy vaults located below the subgrade or finished ground surface, remove tops and walls to a minimum depth of 3 feet below subgrade or 1 foot below finished ground surface. Break up floors and seal remaining drains with masonry or with precast clay or concrete stoppers.

Backfill the cavity created by the removal, partial removal, or emptying operation according to 202.02, except when the cavity lies within the limits of subsequent excavation or other work.

202.08 Underground Storage Tanks Removed. Remove and dispose of underground storage tanks or regulated underground storage tanks, as designated in the Contract Documents, and according to the requirements of the authorities having jurisdiction.

If Item 202 Regulated Underground Storage Tank Removed is specified in the Contract, remove the tank according to the Bureau of Underground Storage Tank Regulations of the Division of Fire Marshal (BUSTR), Ohio EPA, and all applicable Federal, State, and local regulations. Removal includes obtaining the required permit, disposing of the tank and its contents, testing the excavated material, and preparing the closure report. Provide a Certified Tank Installer to supervise the removal. Provide an independent non-Contractor employee BUSTR inspector or a State Certified BUSTR inspector to perform the BUSTR required inspections. For tanks containing hazardous substances other than petroleum, use the Ohio EPA regulations in addition to State Fire Marshal regulations.

Completely remove regulated underground storage tank and contents. Take ownership and dispose of tanks according to 202.02and the above requirements. If because of leakage from the tank, any contaminated water or soil disposal or remediation is required, perform the necessary work under other items in the Contract or according to 109.05.

If Item 202 Underground Storage Tank Removed is specified in the Contract, completely remove and dispose of the tank. Dispose of the removed contents in a manner that conforms to the requirements of the State and local Boards of Health, or other authorities having jurisdiction.

Backfill the cavity created by the removal items according to 202.02, except when the cavity lies within the limits of subsequent excavation or other work.

202.09 Guardrail and Fence Removed. Carefully dismantle and store existing guardrail (including anchor assemblies and terminal assemblies, and any attached posts, signs, and delineators) and fence when designated for reuse or storage by the City. Dispose of wood posts and other materials not considered salvageable according to 202.02.

When fence is designated for replacement, do not remove the existing fence until the replacement material is on site. Begin the new installation within 7 workdays of beginning the removal process.

When guardrail is designated to be replaced and traffic is being maintained in the adjacent lane, do not leave hazards unprotected except for the actual time required to remove the existing guardrail and install the proposed guardrail in a continuous operation. Do not remove the guardrail until the replacement material is on the site and ready for installation. The Engineer will suspend work for failure to comply with this requirement.

Backfill the cavity created by the removal item according to 202.02, except when the cavity lies within the limits of subsequent excavation or other work.

202.10 Manhole, Catch Basin, and Inlet Removed. Remove existing drainage structures of the types designated for removal. Take ownership of castings and dispose of according to Item 202 unless otherwise noted on the plans.

Backfill the cavity created by the removal item according to 202.02, except when the cavity lies within the limits of subsequent excavation or other work.

202.11 Manhole, Catch Basin, and Inlet Abandoned. Remove existing drainage structures of the types designated to be abandoned to a minimum of 1 foot below the finished subgrade or ground surface. Do not damage pipes that are to remain. Take ownership of castings and dispose of according to Item 202 unless otherwise noted on the plans.

Connect existing pipes with new pipe through the structures. Seal the existing inlet and outlet pipes with precast vitrified or concrete stoppers or with masonry of a type and thickness to fill the inlet or outlet pipe.

After connecting or sealing the existing pipes and removing the walls to the required depth, backfill the remaining cavities according to 202.02. If using connecting pipes, carefully hand tamp backfill under and around the pipe according to 202.02.

202.12 Method of Measurement. If the Contract specifies that removal of structures and obstructions is on a lump sum basis, the work will include all structures or obstructions encountered at locations or within areas designated in the Contract Documents. However, the City will measure asphalt wearing course removal on a bridge separate from the lump sum item for structure removal.

If the Contract specifies that removal of specific items is on a unit basis, the City will measure the quantity of each item by the unit stipulated in the Contract. If removal of steps is measured by the foot, the City will measure the number of feet along the front edge of each tread. If the steps have an integral wall, the City will include the thickness of the integral wall with the tread width measurement.

202.13 Basis of Payment. Payment is full compensation for all work involved in the removal and storage, reuse, or disposal of structures and obstructions, including excavation and backfill incidental to their removal, removing the contents of the underground storage and septic tanks and the custody, preservation, storage on the Right-of-Way, and disposal as provided in this specification.

For pipe removed and reused or stored, the City will pay for the accepted work under Item 202 Pipe Removed for Reuse or Storage. For unusable pipe removed, the City will pay for the accepted work under Item 202 Pipe Removed.

If the Contract Documents do not include a pay item for Item 202 Asbestos Pipe Removed, then the City will pay for removal and disposal of asbestos pipe according to 109.05.

When removed pavement is replaced with embankment material, the City will pay for the embankment material under the applicable Item 203 or Item 204 pay item. When pipe is removed from beneath existing pavement, the City will pay for pavement removal under the applicable pay item for pavement removal or excavation, and the City will pay for new pavement under the applicable pavement pay item.

Include all of the costs and work associated with compliance of the rules or regulations under Item 202 Regulated Underground Storage Tanks Removed. If the underground storage tank is not regulated, the work does not include obtaining inspection services, permits, testing excavated material, or closure reporting and the payment will be under Item 202 Underground Storage Tanks Removed.

The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
202	Lump Sum	Structure Removed
202	Lump Sum, Cubic Yard, or Pound	Portions of Structure Removed
202	Foot	Pipe Removed for Reuse or Storage
202	Foot	Pipe Removed
202	Foot	Pipe Filled in Place
202	Foot	Asbestos Pipe Removed
202	Square Yard	Pavement Removed
202	Square Yard	Wearing Course Removed
202	Square Yard	Base Removed
202	Square Foot	Walk Removed
202	Lump Sum, or Foot	Steps Removed
202	Foot	Curb Removed
202	Foot	Curb and Gutter Removed
202	Foot, or Square Yard	Gutter Removed
202	Foot	Curb Removed for Storage
202	Each	Precast Traffic Divider Removed for Reuse or Storage
202	Lump Sum	Building Demolished
202	Each	Underground Storage Tank Removed
202	Each	Regulated Underground Storage Tank Removed
202	Each	Septic Tank Removed
202	Each	Privy Vault Removed
202	Foot	Guardrail Removed
202	Foot	Guardrail Removed for Reuse or Storage
202	Foot	Fence Removed for Reuse or Storage
202	Each	Manhole Removed

202	Each	Manhole Abandoned
202	Each	Catch Basin or Inlet Removed
202	Each	Catch Basin or Inlet Abandoned

ITEM 203 ROADWAY EXCAVATION AND EMBANKMENT

203.01 Description
203.02 Material Definitions
203.03 Restrictions on the Use of Embankment Materials
203.04 General
203.05 Embankment Construction Methods
203.06 Spreading and Compacting
203.07 Compaction and Moisture Requirements
203.08 Earthwork Construction Tolerances
203.09 Method of Measurement
203.10 Basis of Payment

203.01 Description. This work consists of preparing areas upon which embankments are to be placed; excavating for roadways and channels, including the removal of all material encountered not being removed under another item; constructing embankments with the excavated material and material from other approved sources as necessary to complete the planned embankments; furnishing and incorporating all water required for compacting embankment; disposing of unsuitable and surplus material and finishing shoulders, slopes, and ditches.

All excavation is considered unclassified excavation. If the excavation contains regulated materials such as garbage, solid waste, and hazardous waste or material, the Contract Documents will detail the removal for these items.

Use removed or excavated materials in the Work when the material conforms to the specifications; if not, then dispose of the material according to 105.16 and 105.19.

203.02 Material Definitions.

A. Asphalt Concrete. Recycled asphalt pavement (RAP) that is blended to meet the requirements in 703.16.

B. Base. Selected material of planned thickness placed on the subgrade as a foundation for other bases, or asphalt or concrete pavements. The base is a part of the pavement structure.

C. Borrow. Material obtained from approved sources, located outside the construction limits that is required for the construction of the embankment. When borrow is specified or used, use suitable materials that conform to 203.02.R.

D. Compaction Testing. The City will perform the compaction testing of embankment and subgrade according to Supplemental Specification 1501.

E. Embankment. A structure consisting of suitable materials conforming to 203.02.R and constructed in lifts to a predetermined elevation and cross-section.

F. Excavation. The excavation and disposal of all materials required by the Contract Documents.

G. Maximum Dry Density. The maximum dry density is determined according to AASHTO T 99, AASHTO T 272, or Supplemental Specification 1501. The City will use this maximum dry density for compaction acceptance.

H. Natural Granular Materials. Natural granular materials include broken or crushed rock, gravel, sand, durable siltstone, and durable sandstone that can be placed in an 8-inch loose lift.

I. Natural Soil. All natural earth materials, organic or inorganic, resulting from natural processes such as weathering, decay, and chemical action.

J. Optimum Moisture Content. The water content at which the maximum dry density is produced in an embankment material. The optimum moisture content is determined according to AASHTO T 99, AASHTO T 272, or Supplemental Specification 1501.

K. Petroleum Contaminated Soil (PCS). Petroleum contaminated soil (PCS) that is regulated under OAC-1301:7-9-16.

L. Random Material. Mixtures of suitable materials that can be placed in 8-inch loose lifts.

M. Recycled Portland Cement Concrete. Recycled Portland cement concrete (RPCC) that is blended to meet the requirements in 703.16.

N. Recycled Materials. Fly ash, bottom ash, foundry sand, recycled glass, tire shreds, or other materials or manufacturing bi-products not specifically named as suitable materials in 203.02.R.

O. Rock. Sandstone, siltstone, limestone, dolomite, glacial boulders, brick, and RPCC too large to be placed in an 8-inch loose lift.

P. Shale. A fine-grained sedimentary rock formed from the lithification of clay, silt, or mud. Shale has a laminated structure, which splits easily (is fissile). For the purpose of this specification, mudstone and claystone are also considered to be shale. Shale is classified as durable or nondurable according to 703.16.D.

Q. Slag Materials. Slag materials include air cooled blast furnace slag (ACBFS), granulated slag (GS), open hearth (OH) slag, basic oxygen furnace (BOF) slag, and electric arc furnace (EAF) slag meeting the requirements in 703.16.

R. Suitable Materials. All suitable materials are restricted in 203.03. Furnish soil or embankment material conforming to 703.16, when Item 203 Embankment is specified. Furnish material that conforms to 703.16.B or 703.16.C when Item 203 Granular Embankment is specified. Furnish material that conforms to 703.16.C when Item 203 Granular Material Types A, B, C, D, E or F are specified. Do not use recycled materials unless specifically allowed by the Supplemental Specifications.

203.03 Restrictions on the Use of Embankment Materials. Suitable materials are further restricted as follows:

A. Use silt identified as ODOT Group Classification A-4b and RAP only if placed at least 3 feet below the surface of the subgrade.

B. Do not place RPCC and RAP in any location where it would inhibit the growth of vegetation.

C. Do not use any suitable material that cannot be incorporated in an 8-inch lift in the top 2 feet of the embankment.

D. Do not use nondurable shale in the top 2 feet of the embankment that is not completely compacted and pulverized into a soil with 100 percent of the material passing the No. 4 sieve.

E. If using RPCC, OH slag, EAF slag, BOF slags, or blends of these materials, place these materials at least 1 foot below the flow line of the underdrains.

F. Do not use RPCC, OH slag, EAF slag, BOF slags, granulated slag, or blends of these materials for underwater applications.

G. Do not use materials that cannot be satisfactorily placed and compacted to a stable and durable condition.

H. Material excavated in the work that contains excessive moisture is unsuitable for embankment construction unless dried. Dry or aerate such material before incorporating in the work. The Contractor may elect to waste this material, instead of drying it.

I. If Granular Material Type E in 703.16.C is allowed or specified, use a geotextile fabric conforming to 712.09, Type D on the top, bottom, and around the Type E material to prevent piping of the material into the Type E material.

J. If electing to use PCS, submit the information stated below in a suitable format at least 10 workdays before the intended usage.

1. Have an independent consultant that is ODOT pre-qualified in remedial design environmental site assessment review the proposed usage. The consultant shall provide all documentation used to ensure that the proposed usage obeys all Ohio EPA regulations. The consultant shall coordinate all EPA required meetings, documentation, and testing requirements. The consultant shall randomly monitor the construction to ensure that the environmental requirements are carried out on the project. The consultant shall report any discrepancies to the City and the Contractor. The consultant shall certify the report or reports to the City.

2. Use PCS that conforms to all current environmental policies, rules, and regulations and the following:

a. Use PCS material that does not exceed the petroleum constituent concentrations stated below:

Benzene (B)	35 parts per million
Toluene (T)	109 parts per million
Ethyl benzene (E)	32 parts per million
Total Xylenes (X)	165 parts per million

b. Include test results from BTEX testing by using U.S. EPA test method SW 846, method 8020, or an equivalent method.

c. Perform the tests on every 100 tons of PCS used.

203.04 General. Perform the required clearing and grubbing before starting the excavation, grading, and embankment operations.

Coordinate the clearing and grubbing with the installation of sediment and erosion controls that are placed according to Item 207.

Remove all existing pavement and underdrains before the embankment construction.

Temporarily discontinue operations when the excavating operations encounter remains of prehistoric archaeological sites, historical archaeological sites, or human remains. Contact the Engineer and provide notice as required in Section 104.03. The Engineer will contact the appropriate authorities to determine the disposition thereof. Preserve the artifacts or other archeological items or human remains until a determination as to what the disposition and/or removal of such items is made by the Director. Such excavation is considered Extra Work.

If the Contractor encounters any abnormal material such as, but not limited to, drums, tanks, or stained earth or any unusual odors during construction operations, the Contractor shall temporarily discontinue the work in this area, leave equipment in place, cordon off the area, and notify the Engineer. The area is considered to contain hazardous waste or material and must be handled according to *ODOT's Construction Inspection Manual of Procedures*, Item 202 Removal of Structures and Obstructions, Regulated Waste Requirements, Regulated Wastes Found during Construction. Upon notification by the Engineer to resume work, the Contractor may file for an extension of time according to 108.06.

A. Drainage and Maintenance of the Work. Maintain a well-drained embankment and excavation operation. If trenching for narrow widening and in other areas of the embankment construction, construct ditches of an adequate depth and at frequent intervals across the berm or embankment to maintain drainage. Deepen side ditches when necessary to ensure thorough embankment or subgrade drainage.

Construct the embankment with sufficient cross-slope to drain in case of rain.

If precipitation saturates the embankment construction, stay off the embankment construction until the embankment dries or stabilizes. Expedite the construction by removing the saturated embankment or dry the embankment by scarifying, plowing, disking, and recompacting the embankment.

Throughout the embankment construction operation and at the end of each day's operation, shape to drain, compact, and re-compact the work area to a uniform cross-section. Eliminate all ruts and low spots that could hold water.

If using embankment construction or cut areas to haul on, continuously move the hauling equipment around on the area to take advantage of the compactive effort. Continually re-grade and compact the haul roads and maintain the construction according to 105.14.

Plug and cover the upstream ends of all pipe lines encountered during earthwork operations.

B. Rock or Shale Blasting Operations. Conform to Item 208 in the ODOT CMS when blasting.

C. Slides and Breakages. Remove all slides and breakages beyond the limits of the planned finished work when caused by improper excavation methods.

D. Shoulders, Slopes, and Ditches. When specified, place the topsoil in areas to be seeded or sodded according to Item 659. Build shoulders to the lines shown on the plans and to the tolerances specified in 203.08. Reshape shoulders, slopes, and ditches that have been damaged by erosion during construction.

Keep new and existing pavement, and the paved area of the berm clear of earth stockpiles or other berm materials.

E. Pavement Widening Construction. Locate sound pavement edges, and saw-cut pavement to a neat line. Repair and restore damage caused by the equipment or methods. Include the cost of saw-cutting and disposal under Item 203 Excavation.

F. Borrow. Unless otherwise designated in the Contract, make arrangements for obtaining borrow and pay all costs involved. If borrow is specified, use all suitable excavated material in the work prior to using the borrow material.

Place borrow used as embankment according to all the requirements for constructing embankment.

Blade and leave all borrow areas in such shape as to allow accurate measurements after the excavation has been completed.

Notify the Engineer sufficiently in advance of opening any borrow areas so that cross-section elevations and measurements of the ground surface after stripping may be taken.

Construct borrow areas that conform to 105.16; clean up the borrow areas according to 104.07.

G. Staged Construction and Waiting Periods. If specified in the Contract Documents, control the rate of fill accordingly. Adhere to the rate of fill and to the waiting periods during the work.

203.05 Embankment Construction Methods. Embankment construction includes preparing areas upon which embankments are to be placed; placing and compacting approved material within roadway areas where unsuitable material has been removed; and placing and compacting approved material in holes, pits, and other depressions within the roadway.

If scalping is required, scarify, plow, disk, and compact the existing embankment foundation. Compact the top 8 inches of the foundation to 95 percent of the maximum dry density or to a maximum test section dry density according to Supplemental Specification 1501. If the foundation cannot be compacted, the City will design replacement material or the Engineer may increase the lift thickness of the next layer of embankment.

The Engineer may increase the lift thickness of the next embankment layer to bridge the soft or wet foundation areas that will not support the weight of the trucks or hauling equipment. Dump successive loads of rock, durable shale, or granular material in a uniform lift. Do not exceed the thickness required to support the equipment placing the material. Manipulate, blade, distribute, level, and doze the material in place until the area is stabilized and material is above the normal water elevation. Once the bridging has been accomplished, construct the remaining lifts according to 203.06.

If the existing slope is steeper than 8:1, bench into the existing slope as follows:

A. Scalp the existing slope according to Item 201.

B. Cut horizontal benches in the existing slope to a sufficient width to blend the new embankment with the existing embankment and to accommodate the placement, and compaction operations and equipment.

C. Bench the slope as the embankment is placed, and compact into layers.

D. Begin each bench at the intersection of the existing slope and the vertical cut of the previous bench. Recompact the cut materials along with the new embankment.

If constructing embankment on only one side of abutments, wing walls, piers, or culvert headwalls, construct the embankment so that the area immediately adjacent to the structure is not compacted in a manner that causes overturning of or excessive pressure against the structure. If constructing embankment on both sides of a concrete wall, pipe, or box type structure, construct the embankment so that the elevation on both sides of the structure is always approximately the same.

203.06 Spreading and Compacting. Do not construct frozen embankment material or place embankment material on frozen ground.

Spread all embankment material, except for rock in 203.06.C and RPCC in 203.06.D, in successive horizontal loose lifts, not to exceed 8 inches (200 mm) in thickness. Compact all embankment material lifts, except for Type D granular material, Type E granular material, rock and durable shale, to the specified density and moisture controls in 203.07.

When a minimum effective weight requirement is specified in 203.06 or 203.07, the Contractor may use a vibratory roller which meets the requirement using a combination of weight and equivalent centrifugal force from vibration. In all cases, submit documentation from the manufacturer that shows the roller meets the minimum effective weight requirements.

The Engineer may reduce the minimum number of passes if additional passes are detrimental to compaction or stability.

A. Soil and Granular Embankment. For soil or granular material, when a test section is used, use a minimum compactive effort of eight passes with a steel drum roller having a minimum effective weight of 10 tons.

Compact Type D and Type E granular material using at least ten passes of a smooth drum vibratory roller having a minimum effective weight of 10 tons. Add water to Type D granular material as needed or directed by the Engineer.

B. Shale. The Engineer will test shale for durability according to 703.16.D, to determine if compaction testing is required. For nondurable shale, when a test section is used, use a minimum compactive effort of ten passes with a footed drum roller having a minimum effective weight of 15 tons or with rollers meeting the requirements of 703.16.D.

Use water to aid in breaking down large particles and to bring the shale to at least 2 percent above optimum moisture content.

Compact durable shale, as defined in 703.16.D, with a minimum compactive effort of ten passes of a footed drum roller having a minimum effective weight of 15 tons or with rollers meeting the requirements of 703.16.D. When durable shale is mixed with fine material, use fine material that is at least 2 percent above optimum moisture content. No density testing will be required. If shale mixtures contain large particles of shale, break down the particles during placement until the voids are filled.

Place and compact shale and rock mixtures using the same procedure as for shale. Reduce rock size in a shale-rock mixture to less than or equal to 8 inches, or separate rock greater than 8 inches from the mixture and use as rock fill. Use the construction methods for rock when the shale-rock mixture contains less than 15 percent shale.

C. Rock. Reduce the rock until it is small enough to be incorporated into the following horizontal lift thickness: Place rock in a maximum loose lift thickness 6 inches larger than the largest diameter of the rock pieces or 3 feet, which ever results in the smaller lift thickness. When placing rock fill within a length of six times the height of the fill at an abutment, place rock fill in loose lifts not to exceed 18 inches. [For example, if the fill height is 20 feet, then the rock fill within 120 feet of the abutment is placed in less than 18-inch loose lifts.]

Do not dump the rock, but distribute and place the full width of the lift by blading or dozing to ensure proper placement. Evenly distribute the larger rocks, and reduce the voids, pockets, and bridging to ensure minimum deformation. Incorporate smaller rock pieces in the upper portions of each rock lift to fill the voids during this manipulation.

When placing embankment material other than rock on top of the rock lift, level and smooth the rock surface using suitable leveling equipment and evenly distribute the smaller rock, rock spalls, or finer rock fragments.

Roll all rock lift surfaces with eight passes of a vibratory footed drum roller having a minimum effective weight of 10 tons.

When constructing rock and other embankment materials at approximately the same time, perform the following:

1. Use the rock at the base of the embankment.
2. Use rock in the outer portions of the embankment.
3. Use the larger rocks on the outside side slopes.
4. Use the other embankment material in the inner portion of the fill.
5. Keep the top of the other embankment materials higher than the rock.
6. Construct the other embankment materials to a sufficient width to allow the specified compaction.
7. When rock is placed on top of other embankment material, construct the other embankment material at a center-to-side slope grade of approximately 4 percent.

D. Random Materials. Reduce the random material until it is small enough to incorporate into an 8-inch lift, except for RPCC in 203.06.D.1 through 203.06.D.4.

When using a uniformly graded mixture, use material with a moisture content less than 2 percent below optimum to obtain compaction. When large pieces are incorporated in the lifts, use fine material with a moisture content less than 2 percent below optimum to obtain compaction.

Compact natural soil and natural granular material blends with RAP or RPCC to the same requirements as a granular embankment in 203.06.

When using RPCC slabs or large RPCC pieces in the embankment construction, conform to the following:

1. Use natural soil or natural granular material that is less than 2 percent below optimum moisture content in the blend. Reduce the slabs or pieces to less than 3 × 3 feet in size and place the blend in a maximum loose lift thickness of 12 inches.
2. Manipulate, level, and distribute the mixture by blading or dozing to fill the voids and pockets, and reduce bridging.
3. Compact the natural soil or natural granular embankment to the compaction and moisture requirements in 203.07.
4. When the RPCC slabs or large RPCC pieces consists of more than 50 percent of the embankment lift, place the blended material in maximum loose lifts of 18 inches. Do not place one slab directly on the other. Compact, manipulate, level, and distribute as stated in 203.06.D.1 through 203.06.D.3.

E. Areas Inaccessible to Rollers. For areas inaccessible to rollers, such as adjacent to culverts, retaining walls, or other structures, construct the embankment in 6-inch horizontal loose lifts.

203.07 Compaction and Moisture Requirements. Construct all embankments, except rock and durable shale, using moisture and density controls. Unless otherwise specified in the Contract Documents, the Engineer will perform all compaction tests according to Supplemental Specification 1501.

A. Moisture Controls. Sprinkle enough water on embankment material that contains too little moisture to wet it to a moisture content needed to meet the density requirements. Apply the water using tank trucks equipped with suitable sprinkling devices. Thoroughly incorporate the water into the material by using discs, plows, or other approved equipment. Continue to water and to manipulate until the required moisture is uniformly distributed throughout the lift.

Before or during compaction, allow the embankment material that contains excess moisture to dry to a moisture content needed to meet the density requirements. Continue drying until the required moisture is uniform throughout the lift. However, for material that displays pronounced elasticity or deformation under the action of loaded rubber tire construction equipment or other equipment, reduce the moisture content to secure stability. Expedite and manipulate the embankment material by drying the wet embankment material by using plows or discs; by adding dry material, lime or cement; or by other methods.

Do not mix shale in the lifts to reduce the moisture content of the embankment material.

B. Compaction Requirements. Compact all embankment materials, except for rock and durable shale, in horizontal lifts to a dry density greater than the percentage of maximum dry density in Table 203.07-1, or to 98 percent of the maximum dry density determined by the test section methods specified in Supplemental Specification 1501.

TABLE 203.07-1 EMBANKMENT COMPACTION REQUIREMENTS

Maximum Dry Density [lb/ft^3]	Minimum Compaction Requirements in Percent of Maximum Dry Density
90 to 104.9	102
105 to 119.9	100
120 and more	98

If needed for compaction acceptance, construct a test section using the following:

1. Use at least the same number of passes and compactive effort used to construct the test section to construct the production embankment areas.
2. Construct a new test section when the material, supporting foundation, or embankment changes.
3. Reduce the moisture content if the material becomes unstable.

203.08 Earthwork Construction Tolerances. Finish the completed excavation and embankment to the cross sections shown on the plans. Check the excavation and embankment work with templates, slope boards, electronic methods, or other methods specified in Item 623. The Engineer will allow occasional deviations in the work within the following tolerances:

A. When topsoil is specified, use the following:

1. In fill areas, construct the embankment to the bottom of the topsoil depth.
2. In cut areas, excavate additional depth to allow for the topsoil.
3. For cuts or fills, the cross sections show the finished grade, which is the top of the topsoil.

B. For the backslopes (cut slopes), from the back of the ditch to the existing ground, and for the foreslopes (fill slopes), from the edge of the graded shoulder to the bottom of the ditch, do not allow deviations greater than 1 foot as measured in the horizontal plane.

C. Do not construct shoulders and ditches less than the horizontal measurement from the centerline or to a higher elevation than shown on the plans. However, the cross-section may vary below the plan grades by less than ½ inch at the pavement edge and by less than 2 inches elsewhere.

D. Construct or fine grade the subgrade to within 1/2 inch of the plan elevation at any location. Construct or fine grade the subgrade to within 1/2 inch of the plan grade as measured with a 10-foot straightedge applied to the surface parallel to the centerline of the pavement.

E. For all rock or shale cut slopes that do not require control blasting techniques, rake excavate, hoe, ram, or mechanically shape these slopes to obtain a neat and smooth appearance.

203.09 Method of Measurement. The City will measure Excavation by the number of cubic yards of material in the original position, acceptably excavated, using the average end area method.

The City will measure Embankment; Rock; Granular Embankment; and Granular Material, Type ___ by the number of cubic yards of material in the final position, acceptably placed, using the average end area method.

Measurement will include overbreakage or slides not attributable to carelessness of the Contractor, embankment settlement caused by soft embankment foundation, unsuitable materials excavated and removed to obtain proper stability in cut sections and in foundation areas for fill sections.

The City may use three-dimensional measurements where it is impractical to measure material by the cross-section method due to the erratic location of isolated deposits.

The City will not measure excavation or embankment outside plan limits.

The City will measure Borrow by the cubic yard or ton as specified in the Contract Documents.

When in-place density tests are needed, the City will perform the tests according to Supplemental Specification 1501.

The Contract Documents will specify borrow only when the measurement of the material in its final location by volume is impractical. For example, this would apply when the borrow material is to be placed in locations that are under water or in locations with extremely soft foundations. In addition, the City may specify borrow when additional material is needed and when Item 209 is specified. In this case, the City will pay for borrow under Item 209 Borrow.

The City will measure the volume of borrow material in a natural formation either by the average end area method or by weight.

Where measurement is by the average end area, the City will take cross-sections after the surface has been cleared and scalped and again after the borrow area excavation has been completed. The cross-sections determine the volume for payment.

Where the total weight is measured and converted to volume, the City will determine material density in pounds per cubic yard in its original position by a series of representative field measurements made after clearing and scalping have been performed, and as the excavation exposes the borrow material. Weigh the acceptable material, minus excess moisture, excavated from the borrow area for incorporation into the embankment, and furnish the City with load slips. The City will determine the cubic yards for payment by dividing the total weight of the borrow material by the average weight per cubic yard of the undisturbed material. If the moistures of the in-place borrow site density test material is not within 2 percent of the accepted delivered material, the City will calculate volume based on the dry densities and weights.

The City will calculate the volume of borrow from sources other than natural in-place formations, such as processed slag, sand, stone or gravel, and quarry material as follows: Determine the material in-place compacted density in pounds per cubic yard . The volume paid will be the total weight of the material furnished, minus excess moisture, divided by 95 percent of the average embankment density. If the moisture content of the accepted in-place density test material is not within 2 percent of the delivered material, the City will calculate volume based on the dry densities and weights. Where measurements show that completed embankment exists outside the plan cross-sections or outside the allowable tolerances, the City will multiply the quantity outside plan lines by a shrinkage factor to determine the quantity deducted from the measured borrow quantity. The shrinkage factor is determined by dividing the volume or weight of the material excavated or used as borrow by the volume or weight of the material compacted in place.

When the measurement is by weight, the City will accept the material based on the freight bills and weight and volume evidence according to Item 109.

203.10 Basis of Payment. If the Contract does not include Item 201 Clearing and Grubbing or an estimated quantity for Item 201 Tree Removed or Item 201 Stump Removed, or an estimated quantity for the pay items under Item 202, the City will not pay for this work directly but will consider it incidental to pay items under Item 203.

The City will not pay for additional wasting cost of material excavated in the work that was wasted instead of being dried as detailed in 203.03.H.

If the Contractor elects to use PCS, the City will not pay for additional work necessary to comply with the requirements specified in 203.03.J.

If during excavation the Contractor encounters remains of prehistoric archaeological sites, historical archaeological sites, or human remains, the City will pay for such excavation according to 109.05.

If during excavation the Contractor encounters hazardous material or waste, the City will pay according to 109.05.

If necessary during the construction in 203.03.H, 203.04.A, or 203.07.A, the City will not pay for removing the saturated embankment or drying the embankment.

If caused by improper excavation methods, the City will not pay for removing slides and breakages beyond the limits of the planned finished work. The City will pay for the removal of slides and breakages beyond the limits of the planned finished work according to 109.05, when there is no Contractor fault or neglect.

If caused by the lack of implementing erosion controls, the City will not pay for reshaping shoulders, slopes, and ditches damaged by erosion during construction.

If caused by the Contractor's equipment or methods, the City will not pay for repairing or restoring damaged areas designated for salvage.

The City will not adjust earthwork quantities when the volume between two consecutive cross-sections differs by less than 5 percent from the plan quantity. For quantity differences greater than 5 percent, submit supporting documentation to the Engineer. The City will adjust earthwork quantities for changes resulting from the following: undercutting, foundation settlement, changes to grades or slopes, and removing slides.

For quantities measured for payment, the City will use the plan cross-sections, corrected for errors, as the original field cross-sections. Additional cross-sections may be interpolated from the plans at points necessary to more accurately determine quantities.

The City will pay according to 109.05 for changes or extra work that increases the haul distance more than 1/2 mile to the work detailed in the Contract Documents. The City will pay for additional quantities that increase the haul distance 1/2 mile or less at the unit bid price.

When specified, the payment for borrow includes all work to complete the embankment construction to the cross-sections shown on the plans. The City will not make additional payment for the embankment construction of the borrow material. When borrow is not specified, all work is included in the excavation or embankment pay items.

The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
203	Cubic Yard	Excavation
203	Cubic Yard	Embankment
203	Cubic Yard, or Ton	Granular Embankment
203	Cubic Yard, or Ton	Granular Material, Type ___
203	Cubic Yard, or Ton	Borrow
203	Cubic Yard, or Ton	Rock

ITEM 204 SUBGRADE COMPACTION AND PROOF ROLLING / TEST ROLLING

204.01 Description
204.02 Materials
204.03 Compaction of the Subgrade
204.04 Unstable Subgrade
204.05 Rock, Shale, or Coal Subgrade
204.06 Proof Rolling
204.061 Test Rolling
204.07 Spreading and Placing of Materials
204.08 Method of Measurement
204.09 Basis of Payment

204.01 Description. This work consists of preparing suitable subgrade material by drying, compacting, proof rolling, and grading. This work also consists of removing unsuitable subgrade material and constructing new embankment to the limits shown on the plans.

The contract documents provide the anticipated amount of excavation for unsuitable subgrade material which includes unsuitable soil, rock, shale, and coal in the subgrade, and for unstable subgrade material.

Use removed or excavated materials in the Work when the material conforms to the specifications; if not, then dispose of the material according to 105.16 and 105.19.

204.02 Materials. Furnish suitable material conforming to 203.02.R, 203.03, and 703.16, except use soils in the top 12 inches of the subgrade that have a maximum dry density of at least 100 pounds per cubic foot.

Furnish material that conforms to 703.16.B or 703.16.C when Granular Embankment is specified. Furnish material that conforms to 703.16.C when Granular Material, Type ___ is specified, except do not use RPCC, EAF slag, or BOF slag.

Do not use Granular Material Type D, E, or F in the location where underdrains are to be constructed.

Furnish geotextile fabric that conforms to 712.09, Type D. Do not use geotextile fabric in the location where underdrains are to be constructed.

204.03 Compaction of the Subgrade. Compact the subgrade materials that have a maximum dry density of 100 to 105 pounds per cubic foot to not less than 102 percent of maximum dry density. Compact all other subgrade materials to not less than 100 percent of maximum dry density. The Engineer will determine the maximum dry density using AASHTO T 99, AASHTO T 272, or test section method described in Supplemental Specification 1501. Unless otherwise specified in the Contract Documents, the Engineer will perform all compaction tests according to Supplemental Specification 1501. The City may check for compaction before or after the fine grading operation.

If needed for compaction acceptance, use the test section method as follows:

A. Use a minimum of eight passes with a steel drum roller having a minimum effective weight of 10 tons.

B. Use 98 percent of the test section maximum dry density for acceptance of the production subgrade compaction.

C. Use at least the same number of passes and compactive effort used to construct the test section for the production subgrade compaction.

D. Construct a new test section when the subgrade material, supporting foundation or embankment material changes.

E. Reduce the moisture content if the material becomes unstable. The Engineer may reduce the minimum number of passes if the passes are detrimental to compaction.

Use the moisture controls specified in 203.07.A.

Compact the subgrade under pavements to a depth of 12 inches below the subgrade surface and 18 inches beyond the edge of the surface of the pavement, paved shoulders, or paved medians. Compact all subgrades under paved driveways, paved mailbox turnouts, curbs and gutters to a depth of 12 inches below the subgrade surface.

Maintain and drain the subgrade according to 203.04.A.

204.04 Unstable Subgrade. If satisfactory subgrade stability cannot be obtained by moisture control and compaction according to 204.03, the Engineer will direct the Contractor to remove the unstable material and to construct the replacement material to the finished grade within the tolerances specified in 203.08.

Conduct the removal and replacement operations to allow the Engineer to measure the cross-sections before placing the replacement material.

Remove the unstable subgrade material to the depth determined by the Engineer or specified in the Contract Documents. Replace with suitable material according to 204.07.

204.05 Rock, Shale, or Coal Subgrade. If an aggregate base is not a part of the pavement design, excavate the subgrade 2 feet below the final subgrade elevation where rock, shale, or coal is encountered. If an aggregate base is part of the pavement design, reduce the above 2-foot excavation depth by the thickness of the aggregate base or bases. Maintain a total excavation depth of 2 feet below the bottom of the asphalt or concrete pavement.

Excavate for a width of 1 foot beyond the shoulders. Replace with suitable material according to 204.07.

204.06 Proof Rolling. Test the stability and uniformity of the subgrade compaction by proof rolling.

A. Use a proof roller conforming to the following:

1. Four heavy pneumatic tire wheels mounted on a rigid steel frame.

2. Wheels evenly spaced in one line across the width of the roller.

3. Wheels arranged so that all wheels carry approximately equal loads when operated over an uneven surface.

4. A maximum center-to-center spacing between adjacent wheels not exceeding 32 inches.

5. A body for ballast loading capable of varying the gross load from 25 to 50 tons.

6. Tires capable of operating at inflation pressures ranging from 90 to 120 pounds per square inch. Provide a tire pressure gage for measurement before use.

7. Tires filled with liquid from 90 to 95 percent by volume.

Provide ballast that consist of blocks of known weight, sand bags with a weight of 100 pounds, bags of other material of known weight, or other suitable material such that the total ballast weight is readily determinable at all times. Provide sufficient ballast to load equipment to a maximum gross weight of 50 tons.

Furnish the Engineer information verifying that the weights and tire pressures can be met.

B. After compacting the subgrade according to 204.03 and before placing overlying course, proof roll designated subgrade areas. If proof rolling is performed after the underdrains are installed, do not use the proof roller within 1 1/2 feet of the underdrains.

Ensure that the subgrade moisture content at the time of proof rolling is within 2 percent of the moisture used for acceptance in 204.03.

Adjust the load and tire inflation pressure as directed by the Engineer or according to the following:

1. For soils classified as A-3, A-4, A-6, or A-7-6, use a 35-ton roller with a tire pressure of 120 pounds per square inch.

2. For granular soils, and soil, rock, and granular mixtures, use a 50-ton roller with a tire pressure of 120 pounds per square inch.

3. When proof rolling areas where unsuitable or unstable subgrade materials have already been excavated and replaced with granular material, use the weight and tire pressure appropriate for the original subgrade material type.

Measure the tire pressure in the presence of the Engineer.

Operate equipment at a speed between 2 1/2 and 5 miles per hour. Adjust the speed to allow the Engineer to measure the deflections, ruts, or elasticity. Make only one trip of the proof roller over any area. Offset trips to completely cover the subgrade area.

Where proof rolling indicates areas of unstable subgrade, the Engineer will investigate for the source of the problem. The Contractor is responsible for all problems found in the materials constructed under the Contract Documents. Correct all deficiencies found. Correct the subgrade to a uniform and satisfactory stability as directed by the Engineer.

After proof rolling, check the subgrade for conformance to the plans, and correct all surface irregularities. Shape the subgrade within the tolerances specified in 203.08.

204.061 Test Rolling. Perform test rolling to verify the stability and uniformity of the subgrade in a private development, or in areas not specified for Item 204.06. Perform this procedure in the presence of the Engineer.

A. Test Roller. Use a test roller conforming to the following:

1. Tandem axle, dual wheel dump truck.

2. Tire pressure shall be no less than 90 percent of the manufacturer's recommended maximum inflation.

3. The minimum gross weight of the loaded truck shall be 60,000 pounds. Provide a weigh slip.

B. Procedure.

1. Operate equipment at a rate not to exceed 3 to 5 mph or a comfortable walking pace. Adjust the speed to allow the Engineer to measure any deflections and/or areas of rutting.

2. Operate the test roller in a pattern so that all affected areas are loaded with at least one pass.

3. After test rolling, check the subgrade for conformance to the plans, and correct all surface irregularities. Re-shape the subgrade within tolerances specified in 203.08.

C. Evaluation.

1. Rutting up to 1 inch is acceptable, as long as the requirements of Item 203.08 are met. Rutting in excess of 1 inch but not more than 6 inches shall be considered a failure and will require that the soil be reworked and compacted to the required density.

2. Deflection (pumping) up to 1 inch is acceptable. Deflection in excess of 1 inch but not more than 2 inches shall be acceptable if there is not substantial cracking or lateral movement of the soil. Deflection in excess of 2 inches but not more than 6 inches shall be considered a failure, and will require that the soil be reworked and compacted to the required density.

3. Rutting and/or deflection in excess of 6 inches will require review and recommendation for corrective action by an approved Geotechnical Engineer.

4. When remedial work is performed under Item 204.061.C.3, a final test roll shall be performed upon completion of the work. If remedial work is performed as directed under 204.061.C.1 or C.2, a second test roll may be required at the Engineer's discretion.

204.07 Spreading and Placing of Materials. Place materials, conforming to 204.02, in 8-inch loose lifts. The Engineer may increase the lift thickness depending on the stability of the bottom of the excavation. The Engineer may increase the lift thickness up to 24 inches to obtain stability at the top of the lift. Doze, track, or manipulate the material to maximize the density and stability. Once stability is achieved, compact according to 204.03.

When specified, place the geotextile fabric at the bottom of the excavation or at locations designated in the Contract Documents. Place the geotextile fabric smooth and free of tension or wrinkles. Fold or cut the geotextile fabric to conform to curves. Overlap a minimum of 18 inches at the ends and sides. Hold the geotextile fabric in place with pins or staples.

End dump the suitable material on the geotextile fabric. Do not operate the equipment directly on the geotextile fabric. Unless stated otherwise, spread the end dumped material and maintain a minimum lift thickness of 12 inches.

When granular material Type E is specified or allowed, use a geotextile fabric on the top, bottom and around the Type E granular material to prevent piping of material into the Type E granular material. The Engineer may use granular material Type E when excess water is at the bottom of the excavation.

204.08 Method of Measurement. The City will measure Subgrade Compaction by the number of square yards computed from the profile grade and typical sections and actually compacted. The City will measure 18 inches beyond the edge of the pavement surface, paved shoulders, and paved medians. The City will measure the surface area of the paved driveways, paved mailbox turnouts, curb, and gutter.

The City will measure Proof Rolling and Test Rolling, by the number of hours accepted. The City will not measure idle time for repairs, servicing, loading and unloading ballast, adjusting tire pressure, bad weather, wet subgrade, usage at times and at locations other than City directed, and stand-by time to be available when next needed or other cause for stand-by time.

The City will measure Excavation of Subgrade; Embankment; Granular Embankment; and Granular Material, Type ___ according to 203.09. All excavation is unclassified.

The City will measure Geotextile Fabric by the number square yards of surface area of geotextile fabric placed. The City will not measure the specified lap length.

204.09 Basis of Payment. The City will pay according to 109.05 for changes or extra work that increases the haul distance more than a 1/2 mile to the work detailed in the Contract Documents. The City will pay for additional quantities that increase the haul distance 1/2 mile or less at the unit bid price.

If unstable subgrade results from inadequate surface drainage or lack of maintenance, as required by 203.04.A, the City will not pay for replacing the unstable subgrade and disposing of the removed material.

For problems identified in 204.06 that are the result of soils or conditions at lower elevations than the Contract work, the City will pay for the corrections.

The City will pay for the subgrade compaction in areas requiring excavation and replacement in 204.04, 204.05, and 204.07. The City will not pay for subgrade compaction in areas stabilized under Item 206.

The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
204	Square Yard	Subgrade Compaction

204	Hour	Proof Rolling
204	Hour	Test Rolling
204	Cubic Yard	Excavation of Subgrade
204	Cubic Yard	Embankment
204	Cubic Yard	Granular Embankment
204	Cubic Yard	Granular Material Type ___
204	Square Yard	Geotextile Fabric

ITEM 205 CHEMICALLY STABILIZED EMBANKMENT

205.01 Description
205.02 Materials
205.03 Submittals
205.04 Construction
205.05 Mixture Design for Chemically Stabilized Soils
205.06 Method of Measurement
205.07 Basis of Payment

205.01 Description. This work consists of constructing a chemically stabilized embankment by mixing cement or lime into the embankment soil using the method for the specified chemical.

The Contract Documents include an estimated quantity for the specified chemical.

205.02 Materials. Furnish materials conforming to:

Portland cement..... 701.04
Lime (quick lime).....712.04.B

Furnish water conforming to 499.02. Furnish suitable natural soil, from on or off the project site, conforming to 703.16 and 203.03.

205.03 Submittals. Submit, for the Engineer's acceptance, a report that lists the type of equipment to be used, speed of the intended equipment usage, rate of application of the chemical, and calculations that demonstrate how the required percentage of chemical will be applied. Submit the report to the Engineer for acceptance at least 2 workdays before the stabilization work begins.

If the pay item for Mixture Design for Chemically Stabilized Soils is included in the Contract Documents, prepare and submit reports according to City Supplement 1120 and as approved by the Engineer. The testing and verification sampling frequencies in City Supplement 1120 may be modified as directed by the Engineer.

205.04 Construction. Perform chemically stabilized embankment work when the air temperature is 40 °F or above and when the soil is not frozen.

Do not perform this work during wet or unsuitable weather.

Drain and maintain the work according to 203.04.A.

A. Spreading. If the pay item for Mixture Design for Chemically Stabilized Soils is not included in the Contract Documents, use the following spreading percentage rate for the chemical specified by a City approved geotechnical consultant. The percentage is based on a dry density for soil of 115 pounds per cubic foot:

TABLE 205.04-1

Chemical	Spreading Rate
Cement	5 %
Lime (quick lime)	5 %

Spread the chemical uniformly on the surface using a mechanical spreader at the approved rate and at a constant slow rate of speed.

Use a distribution bar with a maximum height of 3 feet above the ground surface. Use a canvas shroud that surrounds the distribution bar and extends to the ground surface.

Minimize dusting when spreading the chemical. Control dust according to 107.23. Do not spread chemical when wind conditions create blowing dust that exceeds the limits in 107.23.

Do not spread the chemical on standing water.

B. Mixing. Immediately after spreading the chemical, mix the soil and chemical by using a power driven rotary type mixer. If necessary, add water to bring the mixed material to between 2 and 4 percent above optimum moisture content for cement, and to at least 3 percent above optimum moisture content for lime. Continue mixing until the chemical is thoroughly incorporated into the soil, all soil clods are reduced to a maximum size of 2 inches, and the mixture is a uniform color.

For areas not under pavements or paved shoulders, the Contractor may use a spring tooth or disk harrow in place of the power-driven rotary type mixer by modifying the above procedure as follows:

1. Open the soil with a spring tooth or disc harrow before spreading.

2. Spread the chemical.

3. Use a minimum disc harrow coverage of ten passes in one direction and ten passes in the perpendicular direction to thoroughly incorporate the chemical into the soil. Continue mixing until all soil clods are reduced to a maximum size of 1 inch and the mixture is a uniform color.

C. Compacting. Construct and compact chemically stabilized embankment according to 203.07, except use 98 percent of the maximum dry density for acceptance.

Determine the maximum dry density for acceptance using the Ohio Typical Moisture Density Curves, the moisture density curves from the Contractor's mixture design submittal, or the maximum dry density obtained by test section method.

205.05 Mixture Design for Chemically Stabilized Soils. When included in the plans, perform a mixture design for chemically stabilized soils according to City Supplement 1120 and as approved by the Engineer.

205.06 Method of Measurement. The City will measure chemically stabilized embankment by the number of cubic yards used in the complete and accepted work, as determined by Item 203.

The City will measure cement and lime by the number of tons incorporated in the complete and accepted work.

205.07 Basis of Payment. The City will pay lump sum for all work, labor, and equipment described in 205.05. The City will pay two-thirds of the lump sum amount bid when the sampling and testing is complete and the report is accepted by the City. The City will pay one-third of the lump sum amount bid when the chemically stabilized embankment is completed and accepted by the City, and the field verification test results are all submitted.

The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
205	Cubic Yard	Cement Stabilized Embankment
205	Cubic Yard	Lime Stabilized Embankment
205	Ton	Cement
205	Ton	Lime
205	Lump Sum	Mixture Design for Chemically Stabilized Soils

ITEM 206 CHEMICALLY STABILIZED SUBGRADE

206.01 Description
206.02 Materials
206.03 Submittals
206.04 Test Rolling
206.05 Construction
206.06 Mixture Design for Chemically Stabilized Soils
206.07 Method of Measurement
206.08 Basis of Payment

206.01 Description. This work consists of constructing a chemically stabilized subgrade by mixing cement or lime into the subgrade soil using the method for the specified chemical. The Contract Documents include an estimated quantity for the specified chemical.

206.02 Materials. Furnish materials conforming to:

Portland cement..... 701.04
Lime (quick lime).....712.04.B

Furnish water conforming to 499.02.

For the curing coat, furnish rapid setting emulsified asphalt conforming to 702.04 or the curing materials specified in 451.02.

206.03 Submittals. Submit a report that lists the type of equipment to be used, speed of the intended equipment usage, rate of application of the chemical, and calculations that demonstrate how the required percentage of chemical will be applied. For phased work, list in the report the procedure to be used to construct the chemically stabilized subgrade to ensure full depth and continuity across phase interfaces. Submit the report to the Engineer at least 2 workdays before the stabilization work begins. City acceptance of the report is not required. The absence of City acceptance does not supersede the Engineer's authority as defined in 105.01.

If the pay item for Mixture Design for Chemically Stabilized Soils is included in the Contract Documents, prepare and submit reports according to City Supplement 1120 and as approved by the Engineer. The testing and verification sampling frequencies in City Supplement 1120 may be modified as directed by the Engineer.

206.04 Test Rolling. When specified, test roll prior to chemical stabilization with test rolling equipment conforming to 204.061, as directed by the Engineer.

206.05 Construction. Perform chemical stabilization work (including the curing period) when the air temperature is 40 °F or above and when the soil is not frozen. Do not perform this work during wet or unsuitable weather.

Where phasing for maintenance of traffic uses part width stabilization of the subgrade, ensure that the required chemical spreading rate, mixing depth, and compaction are provided at the interface between adjacent phases.

A. Spreading. Shape the subgrade to the approximate profile grade prior to spreading the chemical so as to permit the construction of a uniformly compacted course of chemically treated soil to the thickness shown on the plans. The addition of the chemical will raise the subgrade profile approximately 1 inch. Remove this excess material during the fine grading.

Spread the chemical uniformly on the subgrade using a mechanical spreader at the approved rate and at a constant slow rate of speed.

Use a distribution bar with a maximum height of 3 feet above the subgrade. Use a canvas shroud that surrounds the distribution bar and extends to the subgrade.

Minimize dusting when spreading the chemical. Control dust according to 107.23. Do not spread the chemical when wind conditions create blowing dust that exceeds the limits in 107.23.

Do not spread the chemical on standing water.

B. Mixing. Immediately after spreading the chemical, mix the soil and chemical as follows:

1. Cement. Mix the chemical and soil using a power driven transverse type mixer equipped with a computer controlled volumetric water readout. Continue mixing until the cement is thoroughly incorporated into the soil and is a uniform color.

Do not water during the initial mixing.

Perform the initial mixing so that 60 percent of the soil mixture passes the No. 4 sieve and 100 percent passes the 1 inch sieve, exclusive of aggregate larger than the No. 4 sieve size.

After the initial mixing, remix the soil and introduce water through the mixer to bring the mixed material to at least optimum moisture. Uniformly distribute the water in sufficient quantity to hydrate the cement.

If the chemical and soil can be mixed to the required gradation and the water can be added to bring the soil mixture to the required moisture content in one mixing, then only one mixing of the soil, water and chemical is required.

Restrict the addition of water when the moisture content of the soil exceeds 3 percent above optimum moisture. Add water to the mixed soil within 2 hours after the initial mixing.

Once the water is added to the mixture, complete the mixing, compacting, and shaping within 2 hours from start to finish.

2. Lime. Mix the lime and soil using a power driven transverse type mixer equipped with a computer controlled volumetric water readout. If necessary, add water to bring the mixed material to at least 3 percent above optimum moisture content. Continue mixing until the lime is thoroughly incorporated into the soil, all soil clods are reduced to a maximum size of 2 inches, and the mixture is a uniform color.

After the initial mixing, lightly compact the material to seal it against rain or excessive drying by using a steel wheel or pneumatic tire roller.

Allow the lime and soil mixture to cure (mellow) for a period of not less than 24 hours and not more than 7 days. If more than 7 days elapse between initial mixing and final mixing, add an additional 0.5 percent of lime during the final mixing. Furnish the additional lime at no cost to the City unless the delay beyond the 7-day limit is caused by conditions beyond the Contractor's control.

Perform the final mixing until the soil mixture is completely pulverized with all clods reduced to a maximum size of 1 inch and at least 60 percent of the clods passing the No. 4 sieve, exclusive of aggregate larger than the No. 4 sieve. Continue mixing until the lime is uniformly distributed throughout the pulverized soil.

During final mixing, return the mixture to the moisture contents stated above, then shape and compact the mixture.

3. Mixture Depth Check. Check the uniformity of the mix by digging trenches or a series of holes at regular intervals for the full depth of treatment and inspecting the color and depth of the exposed material. Use diluted hydrochloric acid or phenolphthalein to indicate the presence of calcium and ensure that the chemical is mixed to the desired depth.

C. Compacting. Start compaction no more than 30 minutes after the final mixing.

Compact all chemically stabilized subgrade to the requirements in 204.03, except use 98 percent of the maximum dry density for acceptance. Determine the maximum dry density for acceptance by using the Ohio Typical Moisture Density Curves, the moisture density curves from the Contractor's mixture design submittal, or the maximum dry density obtained by test section method. Unless otherwise specified in the Contract Documents, the Engineer will perform all compaction tests according to Supplemental Specification 1501.

Use a vibratory footed roller weighing at least 10 tons.

Use the moisture controls according to 203.07.A, except ensure that the moisture content at time of compaction is at or above optimum.

Perform the final rolling using a smooth drum roller. Do not use vibration during the final rolling.

The Contractor may either shape and fine grade the chemically stabilized subgrade before the curing period, or shape the subgrade before the curing period and fine grade after the curing period. If fine grading before the curing period, fine grade the same day as mixing, compacting, and

shaping. If fine grading after the curing period, shape the subgrade approximately 1 inch above the profile grade and typical sections. In either case, fine grade the subgrade to the profile grade and typical sections within the tolerances in 203.08.

D. Curing. Immediately after the compaction and shaping of the chemically stabilized subgrade, cover the surface with curing coat for curing the chemically stabilized subgrade. Use a rate of 1 gallon per 30 square feet for emulsions or a rate of 1 gallon per 150 square feet when the curing materials in 451.02 are used.

Apply the curing coat before the surface dries. If the curing coat is delayed or the surface starts to dry out, indicated by turning white, apply water for temporary curing until the curing coat can be applied. Do not apply the curing coat unless the curing coat can set up before it rains. When the application of curing coat must be delayed, keep the chemically stabilized subgrade wet by using water until the curing coat can be applied.

Cure the chemically stabilized subgrade for at least five days before the placement of the overlying course.

E. Test Rolling. After the curing period, test roll, as directed by the Engineer, the chemically stabilized subgrade according to Item 204.

F. Protection. Drain and maintain the work according to 203.04.A.

Do not operate any equipment on the chemically stabilized subgrade during the curing period.

Do not allow the chemically stabilized subgrade to freeze during the cure period.

Cover the completed chemically stabilized subgrade with the aggregate base within 60 calendar days.

206.06 Mixture Design for Chemically Stabilized Soils. When included in the plans, perform a mixture design for chemically stabilized soils according to City Supplement 1120 and as approved by the Engineer.

206.07 Method of Measurement. The City will measure chemically stabilized subgrade by the number of square yards computed from the profile grade and typical sections accepted in place.

The City will measure cement and lime by the number of tons incorporated in the complete and accepted work.

The City will measure Curing Coat by the number of square yards computed from the profile grade and typical sections accepted in place.

206.08 Basis of Payment. The City will pay lump sum for all work, labor, and equipment described in 206.06. The City will pay two-thirds of the lump sum amount bid when the soil sampling and testing is complete and the report is accepted by the City. The City will pay one-third of the lump sum amount bid when the chemically stabilized subgrade is completed and accepted by the City, and the field verification test results are all submitted.

The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
206	Square Yard	Cement Stabilized Subgrade, __inches deep
206	Square Yard	Lime Stabilized Subgrade, __ inches deep
206	Ton	Cement
206	Ton	Lime
206	Square Yard	Curing Coat
206	Hour	Test Rolling
206	Lump Sum	Mixture Design for Chemically Stabilized Soils

ITEM 207 TEMPORARY SEDIMENT AND EROSION CONTROLS

207.01 Description
207.02 Materials
207.03 Construction Requirements
207.04 Maintenance
207.05 Performance
207.06 Method of Measurement
207.07 Basis of Payment

207.01 Description. This work consists of constructing temporary sediment and erosion control items as detailed in the plans and in compliance with the Division of Sewerage and Drainage (DOSD) Erosion and Sediment Control Regulation (adopted June 1, 1994) or ordered by the Engineer during the life of the Project to control soil erosion and sedimentation. Control items include, but are not limited to: stabilized construction entrances, filter fabric fence, straw wattles, catch basin and curb inlet protection, sediment traps, basins and dams, sediment riser pipes, straw bales, silt bags, compost filter socks, designated concrete washout areas, slope drains, coarse aggregate, mulches, grasses, filter fabrics, ditch checks and linings, composition berms, geotextiles and other erosion control devises and methods.

To the extent practical, coordinate temporary sediment and erosion control items with permanent control provisions contained in the Contract to ensure continuous erosion control throughout the construction and post-construction periods.

Provide temporary sediment and erosion controls according to Item 207 for construction work outside of the construction limits, such as borrow pit operations, haul roads, equipment and material storage sites, waste areas, and temporary plant sites, at no additional cost to the City.

207.02 Materials. Furnish commercial fertilizer, seed, and mulch materials conforming to Item 659.

Furnish stabilized construction entrances, filter fabric ditch checks, rock checks, inlet protection, perimeter filter fabric fence, silt bags, compost filter socks, designated concrete washout areas, straw wattles, bale filter dikes, sediment basins and dams, dikes, slope drains, and rock channel protection materials as specified on the standard drawings.

Furnish construction ditch and slope protection conforming to the requirements of Item 670. The seeding and mulching of the mats is not required.

Furnish geotextiles conforming to 712.09.

207.03 Construction Requirements. The Storm Water Pollution Prevention Plan (SWPPP) details the placement, location, and description of the temporary and permanent erosion control items. Use the SWPPP along with Item 207 to rearrange and modify the SWPPP and Contract Document quantities to meet the field conditions and to adhere to the National Pollutant Discharge Elimination System (NPDES) permit and the City of Columbus Stormwater Drainage Manual (latest edition).

As a reference for erosion and sediment control Best Management Practices (BMP's), use the current version of the Ohio Department of Natural Resources (ODNR) – Rainwater and Land Development notebook on sediment and erosion control. Ensure that the SWPPP complies with all current provisions of the Ohio Water Pollution Control Act (OWPCA) (ORC Chapter 6111) and the NPDES permit. These requirements apply to areas that do and do not require an NPDES permits.

In the event of conflict between these requirements and pollution control laws, rules, or regulations of other Federal, State, or local agencies, adhere to the more restrictive laws, rules, or regulations.

A. Clearing and Grubbing. Limit the surface area of erodible earth material exposed by clearing and grubbing, excavation, and borrow and fill operations by the amount of erosion control items capable of being placed according to the requirements of this specification. Where attainable, preserve existing vegetation. The Engineer may require construction phasing on large-scale developments.

Within 7 days following clearing and grubbing operations, stabilize all inactive cleared and grubbed areas that are scheduled to remain idle for more than 14 days with construction seed and mulch. At a minimum, use construction seed and mulch on all cuts and fills greater than 20 feet high within 7 days of inactivity. The 20-foot requirement applies when the total inactive acreage exceeds 5 acres.

If an area is within 50 feet of any water body (i.e., stream, river, pond, etc.) and is scheduled to remain idle for more than 14 days, then stabilize the area with construction seed and mulch within 2 days following the clearing and grubbing operations.

On long term projects, temporary seeding is required.

B. Installation of Sediment and Erosion Control Items. Install temporary sediment and erosion control items as detailed and according to the following requirements. Keep the sediment and erosion control items functional until the upper slope drainage areas are fully stabilized.

Construct items 1, 2, and 4 through 7 below according to detailed drawings in the Contract Documents.

1. Perimeter Controls. Use perimeter filter fabric fence or approved equivalent to protect the project from sheet flow runoff from off Right-of-Way and off construction limit locations. Use perimeter filter fabric fence straw wattles or compost filter socks/berms to protect the following project items from sheet flow runoff: water bodies, wetlands, or other significant items shown on the plans.

Use dikes to prevent sediment flow from coming on to the project and to non-vegetated barren areas on the project.

Install perimeter filter fabric fence, stabilized construction entrances, and dikes concurrent with clearing and grubbing operations.

Use diversion swales to redirect or centralize the run-off flow of sediment-laden waters.

2. Inlet Protection. Construct and/or install the inlet protection for the existing inlets at the beginning of construction and for the new inlets immediately after completing the inlet.

Protect all existing storm inlets impacted by the sites active construction.

3. Construction Seeding and Mulching. Apply seed and mulch materials according to Item 659 as modified below. When straw mulch is used, apply at a rate of 2 tons per acre. Seed and mulch during and after construction, and before or during winter shut down to stabilize the areas according to 207.03.A. Fertilize construction seeding areas at one-half the application rate specified in Item 659. If project conditions prevent fertilizing the soil and preparing the seed bed, then the fertilizing and preparation requirements of Item 659 may be waived. Do not place construction seed on frozen ground.

4. Slope Protection. Place dikes, install slope drains, and construct ditches to divert water from bare non-vegetated areas and to protect cut and fill slopes. Place dikes at the top of fill slopes to protect the side slopes from erosion.

For fill slopes, if no filling activity occurs for 3 or more weeks and if slope height is steeper than 8 feet, install dikes and slope drains.

Before cutting the slope, construct a ditch at the top of cut slopes to reduce runoff coming on the slope.

Place the construction slope protection at the locations shown on the plans as the slopes are constructed. Construct according to Item 670.

5. Ditch Checks and Ditch Protection. Place filter fabric ditch checks or rock checks across a ditch and perpendicular to the flow to protect the ditch from erosion and to filter sediment from the flowing water.

Place ditch checks as soon as the ditch is cut. While working on a ditch, place the ditch checks by the end of the day's work.

Install filter fabric ditch checks in ditches for drainage areas less than or equal to 2 acres. Install rock checks in ditches for drainage areas between 2 to 5 acres.

Install ditch checks in conjunction with sediment basins and dams.

Place the construction ditch protection at the locations shown on the plans as the ditches are cut. Construct according to Item 670.

6. Bale Filter Dike. Install fortified* bale filter dike as specified in the Contract Documents, to filter and direct sediment to an appropriate control item before the runoff enters a water body on or off the Project limits. *Fortified with entrenched staked filter fabric or rock

Use the bale filter dike to collect sediment from:

a. Areas less than 1/4 acre for each sediment pit.

b. Slopes with a length of less than 100 feet and having a maximum 2:1 slope.

Use a sediment pit every 100 feet for a 2:1 slope for every 1/4 acre. Use a greater spacing of the sediment pit for flatter slopes.

Begin constructing bale filter dikes within 7 days of commencing grubbing operations. Complete the construction of the bale filter dike before starting the grading operations.

Only fortified Bale Filters are approved.

7. Sediment Basins and Dams. Construct basins and dams at concentrated and critical flow locations to settle out sediment before the water leaves the project. Use basins at the bottom of a ravine, at a culvert inlet, or outlet, along or at the end of a ditch and at any concentrated water exit point of the project. Construct basins to retain 67 cubic yards of water for every acre of drainage area. Use a series of smaller basins or dams as a substitute for a larger basin or dam.

Begin constructing sediment basins and dams within 7 days of commencing grubbing operations. Complete the construction of the sediment basins and dams before starting the grading operations.

All basins shall be fitted with properly engineered and sized, perforated risers. All risers shall be fitted with surface drainage skimmers/floats or approved equivalent.

When specified, construct construction fence around the Sediment Basins or Dams.

8. River, Stream, and Water Body Protection. Protect all streams or water bodies passing through or on the project using perimeter filter fabric fence or bale filter dikes to line the water edge. Divert project water flow using dikes and slope protection. The Contractor may use a combination of items listed in one through seven above and other sediment and erosion control items, as approved by the Engineer.

a. Stream Relocation. Fully stabilize the new stream channel with erosion control mats, or 70 percent grass growth before diverting flow into the new channel. This also applies to ditches that incorporate stream flow.

b. Stream and River Crossings (Causeways). Fording is not allowed. Provide a crossing for construction equipment that does not erode stream banks or allow sediment deposits in the channel. Plan and locate crossings well in advance of needing them. Minimize disturbance to water bodies during construction, maintenance and removal of the stream crossing. Construct the crossings as narrow as practical. Make crossings in shallow areas rather than deep pools where possible. Minimize clearing, grubbing, and excavation of stream banks, bed, and approach sections. Where utility lines cross streams, use dams and bypass pumping.

Construct the stream crossings to a water elevation at least 1 foot above the normal water elevation. If the stream crossing fills more than one-third the width of the stream, then use culvert pipes to allow the movement of aquatic life.

The following minimum requirements apply where culverts are used. Place culverts on the existing stream bed to avoid a drop in water elevation at the downstream end of the pipe. Furnish culverts with a diameter at least two times the depth of normal stream flow measured at the crossing centerline or with a minimum diameter of 18 inches whichever is greater. Furnish a sufficient number of culverts to completely cross the channel from stream bank to stream bank with no more than 10 feet between each culvert.

For all fill and surface material placed in the channel, around the culverts, or on the surface of the crossing, provide clean nontoxic dumped rock fill, Type B, C, or D, as specified in 703.19.B. Extend rock fill up slope from original stream bank for 50 feet to catch and remove erodible material from equipment.

When the causeway is removed, the Contractor may elect to leave the dumped rock fill used around the pipe. Avoid impoundment or a restriction to fish passage when the rock remains. Remove all pipe when the causeway is removed.

207.04 Maintenance. Properly maintain temporary erosion control items with the Engineer's approval. Dispose of silt removed from erosion control items according to Federal, State and local regulations.

The NPDES permit holder or co-permit holders will check temporary and permanent erosion control items every 7 days or within 24 hours after a rainfall of more than 1/2 inch.

A. Perimeter Filter Fabric Fence, Filter Fabric Ditch Checks, Rock Checks, Inlet Protection, Dikes, Designated Concrete Washouts, and Bale Filter Dikes. Remove trapped sediment when it reaches half the height of the lowest section. Make appropriate corrections when the

erosion control items become nonfunctional. Maintain the erosion control items until the up-slope permanent grass coverage is 70 percent or better. At this stage, remove the erosion control items.

B. Sediment Basins and Dams. Remove deposited sediment when sediments reduce the initial volume of the sediment basin or dam by one-half. Make appropriate corrections when these erosion control items fail. Remove dams and basins no sooner than 3 days before placing the permanent seed and mulch on the entire project.

C. Temporary Erosion Control. Remove all temporary erosion control items before the project is accepted. Dispose of the removed materials according to Federal, State and local regulations.

D. Street Cleaning. As directed by the Engineer on an as needed basis, street cleaning is required on all construction projects. This includes maintenance of stabilized construction entrances, sweeping and manual removal of dirt or mud in the street and/or street gutters. The flushing of sediment, mud or any other non-stormwater liquids or materials into the street and/or storm conveyance system is illegal. The cost for Street Cleaning is to be included in the various Item 207 items.

207.05 Performance. For private work, the City holds the Property Owner responsible for the proper installation, maintenance and removal of soil erosion and sediment control items. If the Owner or the Contractor representing the Owner fails to provide proper soil erosion and sedimentation controls, penalties include but are not limited to: holding of sewer permits and inspections, issuance of notices of violation, criminal prosecution and administrative fines.

With the Engineer's concurrence, install additional erosion control items and make adjustments to meet the field conditions and anticipated future work or corrections based on the City's weekly storm water inspections. All erosion and sediment control practices are subject to field modification at the discretion of the City of Columbus and/or the Ohio EPA.

The City will withhold progress payments if proper sediment and erosion controls are not provided and will continue to withhold progress payments until proper erosion controls are placed.

Comply with all applicable Federal, State, and local laws in the conduct of the work. The Contractor represents and warrants that the erosion control items under this item will be performed so as to be in compliance with the requirements of the Clean Water Act, 33 USC Section 1251 *et seq.* and the OWPCA, ORC 6111.01 *et seq.* and related rules. The Contractor warrants and agrees that it is equipped to limit water pollution for its activity according to applicable Federal and State standards.

Provide personnel, equipment, and other services necessary to comply with this requirement and include costs for the same in the bid.

The Contractor further agrees to indemnify and hold harmless the City, and shall reimburse the City for the actual cost of any liability, damage judgment or finding, fine, penalty, or expense as a result of a violation of the above noted laws arising out of the activity of the Contractor in its performance of the Contract.

The Contractor shall reimburse the City within 10 Calendar Days of the amount of the assessment, damage judgment or finding, fine, penalty, or expense, or the City may withhold this amount from the Contractor's next pay estimate and deliver that sum to the permitting agencies issuing the assessment, damage judgment or finding, fine, or penalty.

These assessments are not to be construed as a penalty but are actual damages to recover the costs assessed against the City due to the Contractor's refusal or failure to comply with the above requirements.

These above provisions survive the completion and/or termination of the Contract.

207.06 Method of Measurement. The City will measure fertilizer by the number of tons under Item 659 Commercial Fertilizer.

The City will measure Construction Seeding and Mulching by the number of square yards.

The City will measure Slope Drains by the number of feet.

The City will measure Sediment Basins and Dams by the number of cubic yards of excavation and embankment.

The City will measure Perimeter Filter Fabric Fence, Straw Wattles, Compost Filter Socks/Berms, Bale Filter Dike and Construction Fence by the number of feet.

The City will measure Filter Fabric Ditch Check by the number of feet.

The City will measure Inlet Protection by the number of inlets protected (each).

The City will measure designated concrete washout/s (each).

The City will measure Dikes by the number of cubic yards of excavation and embankment.

The City will measure Construction Ditch Protection and Construction Slope Protection by the number of square yards.

The City will measure Rock Channel Protection, Type C or D (with or without) filter by the number of cubic yards.

The City will measure Sediment Removal by the cubic yards.

The City will measure Stabilized Construction Entrances by the cubic yard.

207.07 Basis of Payment. The City will not pay if temporary erosion and sediment control items are required due to the Contractor's negligence, carelessness, or failure to install permanent controls as a part of the work as scheduled; install such temporary work at no expense to the City.

The City will not pay for stream crossing work specified in 207.03.B.8.b.

If erosion control items in the Contract are properly placed according to the Contract Documents, the City will pay to maintain or replace erosion control items at the unit bid prices or according to 109.05.

The City will pay for sediment removed from dams, basins, inlet protection, ditch checks, rock checks, perimeter filter fabric fence, bale filter dikes, straw wattles, compost filter socks/berms, designated concrete washout areas, and all other types of filter fabrics, straw or hay bales, or any other temporary sediment control items under Item 207 Sediment Removal.

The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
207	Square Yard	Construction Seeding and Mulching
207	Foot	Slope Drains
207	Cubic Yard	Sediment Basins and Dams
207	Foot	Perimeter Filter Fabric Fence
207	Foot	Bale Filter Dike
207	Foot	Filter Fabric Ditch Check
207	Each	Inlet Protection
207	Cubic Yard	Dikes
207	Square Yard	Construction Ditch Protection
207	Square Yard	Construction Slope Protection
207	Cubic Yard	Rock Channel Protection Type C or D with Filter
207	Cubic Yard	Rock Channel Protection Type C or D without Filter
207	Cubic Yard	Sediment Removal
207	Foot	Construction Fence
207	Square Yard	Geo-textiles
207	Cubic Yard	Stabilized Construction Entrance
207	Foot	Straw Wattles
207	Foot	Compost Sock/Berm
207	Each	Designated Concrete Washout Area

ITEM 209 LINEAR GRADING

209.01 Description
209.02 Materials
209.03 Construction Requirements
209.04 Ditch Cleanout
209.05 Reshaping under Guardrail
209.06 Preparing Subgrade for Shoulder Paving
209.07 Grading Tolerances
209.08 Method of Measurement
209.09 Basis of Payment

209.01 Description. This work consists of performing linear grading within the specified alignment detailed in the Contract Documents and within the grading tolerances.

Use removed or excavated materials in the Work when the material conforms to the specifications; if not, then dispose of the material according to 105.16 and 105.19.

209.02 Materials. Furnish suitable materials as defined in 203.02.R.

209.03 Construction Requirements. Construct embankment and subgrade work according to Item 203 and 204.

209.04 Ditch Cleanout. Reestablish the cross-section of the existing ditch. Use the required embankment material to fill the eroded conditions. The compaction requirements specified in Item 203 do not apply.

209.05 Reshaping under Guardrail. Reshape graded shoulders at locations where the existing guardrail is removed or where the new guardrail is to be erected to ensure a smooth, drainable surface free of all irregularities.

209.06 Preparing Subgrade for Shoulder Paving. Prepare the subgrade for shoulder paving by excavating the existing shoulder material to the depth shown in the plan. Trim unsound or broken edges of asphalt concrete or concrete pavement to a line established by the Engineer. Remove any unstable material and shape and compact the subgrade.

Compact the subgrade according to 204.03. Backfill areas graded in excess of the depth shown on the plans with Item 617 compacted aggregate at no expense to the City.

209.07 Grading Tolerances. Do not encroach on stream channels, impact wetlands, or extend beyond construction limits, Right-of-Way or easement limits. Do not make alignment or profile grade adjustments that adversely affect drainage. Construct the work to the tolerances in 203.08.

209.08 Method of Measurement. The City will measure Linear Grading, Reshaping under Guardrail, and Preparing Subgrade for Shoulder Paving by the number of linear feet completed and accepted, along each side of the pavement. The City will make deductions for intersections and other gaps in the Work.

The City will measure Ditch Cleanout by the number of linear feet measured along the centerline of the ditch.

The City will measure Borrow according to 203.09.

209.09 Basis of Payment. The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
209	Linear Feet	Linear Grading
209	Linear Feet	Ditch Cleanout
209	Linear Feet	Reshaping under Guardrail
209	Linear Feet	Preparing Subgrade for Shoulder Paving
209	Cubic Yard, or Ton	Borrow

250 PAVEMENT REPAIRS

ITEM 251 PARTIAL DEPTH PAVEMENT REPAIR

251.01 Description
251.02 Removal of Existing Pavement
251.03 Placement of Asphalt Concrete
251.04 Method of Measurement
251.05 Basis of Payment

251.01 Description. This work consists of partial depth removal of existing asphalt pavement in areas exhibiting deterioration at the surface, applying tack coat, and placing and compacting asphalt concrete.

251.02 Removal of Existing Pavement. The Engineer will designate the location and limits of areas to be repaired. Provide the Engineer with aerosol spray paint to outline those areas for repair. Construct rectangular repair areas with dimensions as required to envelop surface deterioration. Unless otherwise specified, extend repair areas the full width of a traffic lane. Remove pavement to the depth shown on the plans.

Remove the pavement to the specified depth within the designated limits without loosening or otherwise damaging adjacent pavement. Dispose of removed pavement according to 202.

Trim the limits of the repair to form a vertical face 1.5 inches deep from the surface unless the repair is covered with a mill and overlay within 60 days.

251.03 Placement of Asphalt Concrete. Apply 407.02 material to thoroughly coat the exposed surface and to fill cracks and joint openings.

In accordance with Standard Drawing 1441, place and compact approved asphalt concrete meeting the design requirements of the item shown in the pay item description in one or more lifts as necessary to finish flush with the adjacent pavement surface. Place surface course mixes at a maximum 2 inch lift thickness and intermediate courses at a maximum 3 inch lift thickness.

Thoroughly and uniformly compact all lifts using suitable mechanical compaction equipment operated over the entire replacement area to produce a smooth surface flush with the adjacent pavement surface.

Ensure that each lift is thoroughly compacted to a suitable density that will not result in displacement under traffic. If the Contract does not include resurfacing, seal the perimeter surface of the repaired area by applying a nominal 4 inch strip of approved 702.17.B or 702.17.C material.

251.04 Method of Measurement. The City will measure the quantity of Partial Depth Pavement Repair by the number of square yards or cubic yards of pavement repaired in the complete and accepted work, calculated using the dimensions established by the Engineer.

251.05 Basis of Payment. Payment is full compensation for furnishing all materials, including aerosol spray paint, tack coat, asphalt concrete, and perimeter seal; and cutting, removing, and disposing of existing pavement.

The City will pay for accepted quantities at the contract price as follows:

Item	Unit	Description
251	Square Yard	Partial Depth Pavement Repair (441)
251	Cubic Yard	Partial Depth Pavement Repair (441)

ITEM 252 FULL DEPTH RIGID PAVEMENT REMOVAL AND FLEXIBLE REPLACEMENT

252.01 Description
252.02 Removal of Existing Rigid Pavement
252.03 Correction of Subgrade
252.04 Placement of Asphalt Concrete
252.05 Method of Measurement
252.06 Basis of Payment

252.01 Description. This work consists of the full depth removal of existing rigid pavement, correcting the subgrade, placing and compacting asphalt concrete, and restoring the shoulders.

252.02 Removal of Existing Rigid Pavement. Conform to 255.03, except the last paragraph does not apply.

252.03 Correction of Subgrade. Shape and recompact the subgrade as the Engineer directs. Clean all vertical faces of the existing pavement, and coat them with asphalt material according to 401.14.

252.04 Placement of Asphalt Concrete. In accordance with Standard Drawing 1441, construct the pavement replacement by placing and compacting Item 301 and 441 material in two or more lifts.

Thoroughly and uniformly compact all lifts using suitable mechanical compaction equipment operated over the entire replacement area to produce a smooth surface flush with the adjacent pavement surface.

Ensure that each lift is thoroughly compacted to a suitable density that will not result in displacement under traffic.

If the Contract does not include resurfacing, seal the perimeter surface of the repaired area by applying a nominal 4 inch wide strip of approved 702.17.B or 702.17.C material.

After completing repairs, restore the existing shoulders to the condition that existed prior to the repair work.

252.05 Method of Measurement. The City will measure the quantity of Full Depth Rigid Pavement Removal and Flexible Replacement by the number of square yards or cubic yards of rigid pavement repaired in the complete and accepted work, calculated using the dimensions established by the Engineer.

The City will measure the quantity of Full Depth Pavement Sawing by the number of feet of full depth saw cuts in the complete and accepted work. The City will not measure offset saw cuts. The City will not measure additional cuts made to facilitate the removal of the pavement.

252.06 Basis of Payment. Payment is full compensation for furnishing all materials, including aerosol spray paint, removing pavement, correcting the subgrade, placing flexible pavement, sealing, and restoring the shoulders.

The City will not pay for removal, disposal, and replacement of pavement damaged adjacent to the repair.

Include the cost of any additional concrete sawing and removal depths less than 1 inch greater than those shown in the plans.

The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
252	Square Yard	Full Depth Rigid Pavement Removal and Flexible Replacement
252	Cubic Yard	Full Depth Pavement Removal and Flexible Replacement
252	Foot	Full Depth Pavement Sawing

ITEM 253 PAVEMENT REPAIR

253.01 Description
253.02 Removal of Existing Pavement
253.03 Placement of Asphalt Concrete
253.04 Method of Measurement
253.05 Basis of Payment

253.01 Description. This work consists of removing existing asphalt concrete, brick, PCC, or aggregate pavement courses; shaping and compacting the exposed material; and placing new asphalt concrete pavement or aggregate and asphalt concrete pavement courses.

Refer to Standard Drawing 1441 and the plans for details about the repairs and replacement material.

253.02 Removal of Existing Pavement. The Engineer will designate the location and limits of areas to be repaired. Provide the Engineer with aerosol spray paint to outline those areas for repairs. Repair the full depth of the pavement, unless otherwise shown on the plans.

Cut the existing pavement at the limits specified and as necessary to prevent disturbing or undermining the remaining pavement during removal. Completely remove pavement in the repair area to the specified depth without displacing, undermining, or otherwise damaging the remaining pavement. Dispose of removed pavement according to 202.

Trim the limits of the repair to form a vertical face 1.5 inches deep from the surface unless the repair is covered with a mill and overlay within 60 days.

253.03 Placement of Asphalt Concrete. Shape and compact the exposed underlying material as the Engineer directs. Before placing specified asphalt concrete, clean all vertical faces of the existing pavement and coat them with asphalt material according to 401.14. Place the replacement material in lifts as the Engineer directs. Thoroughly and uniformly compact each lift using suitable compaction equipment as the Engineer directs. Finish the final lift flush with the adjacent pavement surface.

Thoroughly and uniformly compact all lifts using suitable mechanical compaction equipment operated over the entire replacement area to produce a smooth surface flush with the adjacent pavement surface.

Ensure that each lift is thoroughly compacted to a suitable density that will not result in displacement under traffic.

If the Contract does not include resurfacing, seal the perimeter surface of the repaired areas by applying a nominal 4 inch wide strip of approved 702.17.B or 702.17.C material.

After completing repairs, restore the existing shoulders to the condition that existed prior to the repair work.

253.04 Method of Measurement. The Engineer will measure the quantity of Pavement Repair by either the number of square yards or cubic yards of pavement repaired in the complete and accepted work, calculated using the dimensions established by the Engineer.

253.05 Basis of Payment. Payment is full compensation for furnishing all materials, including aerosol spray paint and replacement and restoration materials; cutting, removing, and disposing of existing pavement; shaping and compacting the exposed underlying material; placing new pavement; and restoring the shoulders.

The City will not pay for additional work to repair damage caused by the pavement sawing or pavement removal.

The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
253	Square Yard	Pavement Repair
253	Cubic Yard	Pavement Repair

ITEM 254 PAVEMENT PLANING

254.01 Description
254.02 Equipment
254.03 Planing
254.04 Surface Patching
254.05 Surface Tolerances
254.06 Method of Measurement
254.07 Basis of Payment

254.01 Description. This work consists of planing asphalt concrete and disposing of the cuttings, and, if specified in the Contract, patching the planed surface.

254.02 Equipment. Use self-propelled planing equipment that has sufficient power and stability to consistently and efficiently meet the requirements of 254.05 and the plans. Use equipment with either grinding, sawing, or milling type cutters. Ensure that the cutters are mounted rigidly to the carrier and are adjustable to control the depth of cut and cross-slope. Use equipment with a suitable carrier wheelbase or with an automatic control system having an external reference. Ensure that cross-slope adjustments or automatic controls are capable of producing either a variable or a constant cross-slope, as required.

For small or confined areas, the Contractor may use suitable supplemental equipment or methods approved by the Engineer.

254.03 Planing. Make one or more planing passes, as necessary, over the designated area to the depth specified in the plans. Remove irregularities such as bumps, corrugations, and wheel ruts, when required, to establish a new pavement surface elevation or cross-slope.

Remove cuttings from the surface following each pass. Before opening the completed area to traffic, thoroughly clean the surface of all loose material that would create a hazard or nuisance, or would redeposit into the surface texture. Dispose of cuttings according to 202.

Implement effective measures to control dust, pavement contamination, and the scattering of loose particles during planing and cleaning operations.

If planing damages the adjacent pavement, repair the damaged area to the Engineer's satisfaction. Ensure that the repaired area matches the adjacent pavement in terms of smoothness and mix type.

254.04 Surface Patching. Patch areas of the planed surface that the Engineer designates that have spalling or dislodged unsound pavement. Before patching, clean areas of loose material, coat with 407.02 asphalt material, and fill with Item 441 Surface or 442 9.5mm or 12.5mm material. Level and compact new material flush to the adjacent planed pavement.

254.05 Surface Tolerances. Plane the surface free from grooves, ridges, gouges, or other irregularities detrimental to the safe operation of vehicles on the planed surface.

If the Contract specifies planing without resurfacing, plane the surface to a smoothness of 1/8 inch in 10 feet. If the Contract specifies resurfacing after planing, plane the surface to a smoothness of 1/4 inch in 10 feet. Match the surfaces at the edges of adjacent passes within 1/8 inch. Ensure that the cross-slope of the planed surface is within 3/8 inch in 10 feet of the specified cross-slope.

254.06 Method of Measurement. The Engineer will measure the quantity of Pavement Planing, Asphalt Concrete by the number of square yards.

The Engineer will measure the quantity of Patching Planed Surface by the number of square yards.

254.07 Basis of Payment. The City will not pay for repairs due to damage caused by planing operations. If the depth of the planed surfaces is increased by more than 3/8 inches, the City will compensate for the additional work.

The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
254	Square Yard	Pavement Planing, Asphalt Concrete
254	Square Yard	Patching Planed Surface

ITEM 255 FULL DEPTH PAVEMENT REMOVAL AND RIGID REPLACEMENT

255.01 Description
255.02 Materials

255.03 Removal of Existing Pavement
255.04 Correction of Subgrade
255.05 Placing Dowels and Tiebars
255.06 Placement of Portland Cement Concrete
255.07 Wearing Course Replacement
255.08 Opening to Traffic
255.09 Method of Measurement
255.10 Basis of Payment

255.01 Description. This work consists of full depth removal of existing pavement; removing subbase where specified; compacting the subgrade; furnishing and placing dowels, tiebars, and mesh where specified; placing, consolidating, finishing, and curing new PCC to the level of the adjacent PCC pavement; replacing existing asphalt overlay where required; and restoring affected shoulders.

Refer to Standard Drawing 1441 and the plans for details about the repairs and replacement material.

255.02 Materials. Furnish materials conforming to:

Concrete, Class FSCOC 1, COC MS, COC FS 499
Curing materials, Type 2 ..... 705.07
Non-shrink non-metallic grout 705.20
Reinforcing steel 709.00
Preformed elastomeric joint sealer 705.11
Tiebar ..... 705.01 or 709.00
Dowel bars and basket assemblies ..... 705.01 or 709.13
Expansion shield anchors Type A 712.01
Tack Coat ..... 702.04 or 702.13
Crack Seal 705.04
Asphalt 441

Use epoxy coated hook bolt, wiggle bolt, and coupling.

Select and furnish grout from the Qualified Product List issued by the Laboratory that firmly anchors the dowel or tiebar within 30 minutes.

255.03 Removal of Existing Pavement. The Engineer will locate and mark all areas for repair before the start of diamond sawing. Provide the Engineer with aerosol spray paint to outline those areas for repair.

Saw cut the existing rigid pavement to the full depth at the limits of the area designated by the Engineer using a diamond saw blade. Where there is an existing asphalt concrete overlay on top of the concrete pavement to be removed, the Contractor may make either a full depth saw cut through the asphalt concrete overlay and the concrete pavement, or make an offset saw cut through the asphalt concrete overlay. If making an offset saw cut through the asphalt concrete overlay, remove the overlay as necessary to provide clearance for the full depth saw cut through the concrete pavement. The Contractor may elect to make additional cuts to facilitate the removal of the pavement.

Remove pavement in the repair area by the lift-out method without damaging or undermining the remaining pavement. After the repair area is isolated by full depth saw cuts, drill holes through the deteriorated slab, and install lift pins. Vertically lift the pavement out of the repair area. Remove loose debris left behind after lift-out using hand methods. Dispose of removed pavement according to Item 202.

Do not break the pavement and clean out the material using a backhoe unless the Engineer determines that the lift-out method is not feasible due to deteriorated pavement or existing asphalt concrete repairs.

If the bottom face of the adjacent concrete pavement is deteriorated for a height greater than one-fourth (1/4) the thickness of the rigid pavement, make additional full depth saw cuts as directed by the Engineer along the full width of the lane or lanes to remove the deteriorated areas. Repair pavement damaged during the pavement sawing or pavement removal according to Item 255 or Item 256.

255.04 Correction of Subgrade. After removing the pavement full depth and before installing dowels or tiebars, shape and recompact the subgrade to the satisfaction of the Engineer. Use concrete to replace any subgrade material removed as part of the rigid pavement replacement.

255.05 Placing Dowels and Tiebars. Drill dowel and tiebar holes using hydraulic, electric, or pneumatic percussion drills without spalling or damaging the existing concrete. Provide drills capable of independent adjustment of each drill shaft in the horizontal and vertical direction. To drill for dowels, use a device capable of drilling a minimum of three holes at a time. For patches 10 feet or greater in length, provide tie bars or wiggle bolts of the size and spaced as shown on the standard drawings along the longitudinal joint(s). Blow all drilled holes clean with oil-free compressed air. Maintain holes dry and frost free before grouting the dowels or tiebars. Pneumatically inject grout starting at the rear of the drilled holes and drawing a bead of material towards the front. Inject a sufficient amount of grout to fill all voids around the dowels and tiebars. Use a grout retention disc with a radius slot as shown in the standard drawings to retain the grout within the drilled holes. Place the grout retention disc on the dowels and tiebars at the end to be inserted in the hole. Insert dowels and tiebars in the holes and rotate the dowels and tiebars approximately one full revolution. Ensure a small amount of grout extrudes through the radius slot in the grout retention disc when the dowels and tiebars are installed. Hold dowel bars in proper alignment until the grout has hardened.

255.06 Placement of Portland Cement Concrete. Do not place any PCC rigid pavement replacement until the grout around the dowels and tiebars has hardened. Coat dowel bars with bond breaking material conforming to 451.09.B. Place PCC according to 451.07. Use forms when placing portland cement concrete against asphalt concrete or any unbound material. Cast each patch in one continuous operation. Consolidate the

concrete around the perimeter of the patch and within the limits of the patch area using an internal type vibrator. Use approved internal type vibrators capable of visibly affecting the concrete for a distance of 12 inches from the vibrator head.

Screed repairs less than 12 feet in length parallel to the centerline. Screed repairs 12 feet in length and longer perpendicular to the centerline.

While the concrete is still in a plastic state, test the surface for trueness and for being flush with the edges of the adjacent slabs using a 10-foot straightedge. Place the straightedge parallel to the pavement centerline with half of the straightedge resting on the adjacent pavement, and draw the straightedge across the patch to test the patch edges. Check areas within the patch length in a similar manner. Where the straightedge shows deviations, correct all high or low areas exceeding 1/8 inch in 10 feet. Recheck the concrete surface after making corrections to ensure conformance to the above tolerance. Make additional checks and corrections until patch is within tolerance.

Texture the new concrete surface similar to that of the surrounding pavement.

Apply the liquid membrane-forming curing compound at a minimum rate of 1 gallon of material for each 150 square feet.

255.07 Wearing Course Replacement. Trim the limits of the repair to form a vertical face 1.5 inches deep from the surface. Replace the removed asphalt concrete overlay with an approved Item 441 material, or as shown on the plans. Compact the material as approved by the Engineer using any of the roller types specified in 401.13. Apply Item 407 Tack Coat to the replacement surfaces.

Before opening the rigid replacement to traffic, restore the shoulders to the original line and grade. Use either aggregate or asphalt concrete as shown on the plans or as the Engineer directs. Fill the low areas, and compact them flush with the surrounding shoulder.

Seal the perimeter surface of the repaired areas by applying approved 705.04 material.

If the contract includes resurfacing, one lift of intermediate course may be used up to 3 inches to match the existing pavement and it is not required to seal the perimeter surface.

255.08 Opening to Traffic. Do not open the rigid replacement to traffic until the concrete attains a split tensile strength of 350 pounds per square inch, as tested per ASTM C496.

If maintaining traffic in adjacent lanes, schedule work in order to place the concrete in the prepared repair area within 48 hours after removing pavement.

If unable to complete placement of the concrete in the exposed repair area by the end of a daily work shift, fill or cover repair areas less than 4 feet from the traveled lane. Fill using a temporary patch material suitable to the Engineer or cover unfilled repair areas 10 feet or less in length with a steel plate.

Do not leave repair areas unfilled with concrete when work is suspended on weekends or holidays. If unable to complete placement of the concrete in the exposed repair area before suspending work for a weekend or holiday or within the 48-hour time specified above, fill the repair area with an asphalt concrete mixture or other suitable temporary patch material with a durable surface as the Engineer directs. Maintain the temporary patches while they are in service.

255.09 Method of Measurement. The City will measure the quantity of Full Depth Pavement Removal and Rigid Replacement by the number of square yards or cubic yards repaired in the complete and accepted work.

The City will measure the quantity of Full Depth Pavement Sawing by the number of feet of perimeter full depth saw cuts in the complete and accepted work. The City will not measure offset saw cuts. The City will not measure additional cuts made to facilitate the removal of the pavement.

255.10 Basis of Payment. Payment is full compensation for furnishing all materials, including paint; removing pavement by any method; removing subbase for undercut replacement; compacting subbase and subgrade; placing rigid pavement, including concrete necessary to replace removed subbase or subgrade; furnishing and placing dowels, tiebars, and mesh; placing, maintaining, removing, and disposing of temporary patches, and restoring the shoulders.

The City will not pay for additional concrete sawing and removal depths within 1 inch greater than those shown on the plans.

The City will not pay for additional work to repair damage caused by pavement sawing, pavement drilling or pavement removal.

Payment is full compensation for furnishing all materials, including tack coat and asphalt concrete.

The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
255	Square Yard	Full Depth Pavement Removal and Rigid Replacement, Class ___
255	Cubic Yard	Full Depth Pavement Removal and Rigid Replacement, Class ___
255	Foot	Full Depth Pavement Sawing

ITEM 256 BONDED PATCHING OF PORTLAND CEMENT CONCRETE PAVEMENT

256.01 Description
256.02 Materials

256.03 Equipment
256.04 Removal of Unsound Concrete
256.05 Preparation of Patch Area
256.06 Bonding Grout Installation
256.07 Placing Patching Material
256.08 Curing and Loading
256.09 Method of Measurement
256.10 Basis of Payment

256.01 Description. This work consists of bonded patching of PCC pavements at spall areas adjacent to cracks or joints or other areas of the pavement as designated by the Engineer. This work involves removing all loose and unsound concrete and asphalt material patches; removing sound concrete as directed; preparing the surface; applying a bonding grout if required; reconstructing the joint or crack; and mixing, placing, finishing, and curing of the patching material called out in the pay item description.

256.02 Materials. Furnish materials conforming to:

Portland cement..... 701.05
Fine aggregate..... 703.02
Coarse aggregate, No. 8 size 703.02
Curing material..... 705.07
Air-entraining admixture..... 705.10
Quick setting concrete mortar 705.21

256.03 Equipment. Use a milling machine, concrete saw, jackhammers, or other approved equipment to remove existing surface material. Provide oil and moisture free compressed air for cleaning and abrasive blasting the prepared area. Provide an on-site concrete mixer capable of mixing a minimum of 2-cubic foot batches of patching material. Provide chipping hammers not heavier than the nominal 35-pound class.

256.04 Removal of Unsound Concrete. The Engineer will locate and mark all areas to be repaired prior to concrete sawing. Provide the Engineer with aerosol spray paint to outline the areas for repair. Repair areas will be rectangular or square in shape with dimensions as required to envelope the surface deterioration.

Saw the perimeter of all areas designated for removal to a depth of 1 inch to produce a vertical or slightly undercut face. Make additional saw cuts as required to facilitate removal. Remove all unsound concrete, all asphalt material, and all obviously loose and disintegrated concrete within the patch area. Remove sound concrete where required to achieve the minimum depth within the patch area. Remove concrete by jack hammering or milling. The minimum depth of any partial depth repair is 1 1/2 inch except at the perimeter saw cuts. Operate chipping hammers at an angle of less than 45 degrees measured from the surface of the pavement. During removal of unsound concrete, remove all pavement reinforcing exposed in the patch areas using a cutting tool or a torch.

256.05 Preparation of Patch Area. Before placing the patching material or before applying the bonding grout, if used, abrasive blast the exposed concrete surfaces to which the patching material is to bond until free of loose particles, oil, dust, traces of asphalt concrete and joint sealer, and other contaminates. Do not begin abrasive blasting operations until implementing reasonably available engineering controls to limit fugitive dust that are acceptable to the Engineer. Conform to State, regional, and local government agency requirements regarding control of dust generated by the blasting operation. Remove all sandblasting residue with compressed air just prior to placing the patching material or just prior to applying the bonding grout, if used. For Types B and C patching materials that do not use water as the activator, perform additional surface preparation according to the patching material manufacturer's recommendations.

Recreate joints and cracks through or along the patch using a joint board that extends below the prepared surface and has a width equal to the existing joint or crack. One hour after placing the patching material, remove the joint board in a manner that does not damage the patch.

256.06 Bonding Grout Installation. For bonding Type A patches, use grout that consists of equal parts, by volume, of portland cement and sand, mixed with sufficient water to form a stiff slurry. Using a stiff brush or broom, apply a thin, uniform coating of grout to the prepared surface. Scrub the grout onto the dry surfaces of the prepared area to be patched immediately before placing the patching material. Do not allow excess grout to collect in low spots. Do not allow the grout to dry before placing the new concrete. Paint grout over all sawed joints between the patch and adjacent concrete immediately after completing the finishing.

For bonding Types B and C patches, conform to the patching material manufacturer's recommendations.

256.07 Placement of Patch Material. Use Type A, B, or C patch material as follows:

A. Type A. Provide patch material consisting of one part high early strength portland cement, one and a half parts fine aggregate, and one and a half parts coarse aggregate by volume. Add sufficient air-entraining admixture to maintain an air content of 8 ± 2 percent. Add enough water to obtain the minimum slump practical for placing, and do not allow slump to exceed 4 inches. Mix the materials on site. Do not use ready-mixed concrete. Place the concrete mixture in the patch area while the bonding grout is still wet. Slightly overfill, vibrate, and strike off the concrete.

B. Type B. Provide patch material consisting of quick setting concrete mortar 705.21, Type 1 or 2. Mix and place the mortar according to the manufacturer's recommendations. Add coarse aggregate, as needed, according to the manufacturer's instructions. Place the concrete mixture in the patch area. If the manufacturer's requirements specify using bonding grout, place the concrete mixture while the bonding grout is still wet. Slightly overfill, vibrate, and strike off the concrete.

C. Type C. Provide patch material consisting of a blend of quick setting concrete mortar 705.21, Type 2 and selected aggregates with an activator. Mix and place these materials according to the manufacturer's recommendations. Add coarse aggregate, as needed, according to the

manufacturer's instructions. Place the concrete mixture in the patch area. If the manufacturer's requirements specify using bonding grout, place the concrete mixture while the bonding grout is still wet. Slightly overfill, vibrate, and strike off the concrete.

Screed patches 12 feet and less in length parallel to the centerline. Screed patches over 12 feet in length perpendicular to the centerline.

While the concrete is still in a plastic state, test the surface for trueness and for being flush with the edges of the adjacent slabs using a 10-foot straightedge. Place the straightedge parallel to the pavement centerline with the ends resting on the adjacent pavement and draw the straightedge across the patch. Where the straightedge shows deviations, correct all high or low areas exceeding 1/8 inch in 10 feet. Recheck the concrete surface after making corrections to assure that the patch area meets the surface tolerance before the patching material hardens.

Texture the new concrete surface similar to that of the surrounding pavement.

256.08 Curing and Loading. Cure Type A patches according to 451.11, except allow the patch to attain a split tensile strength of 350pounds per square inch, as tested per ASTM C496, before opening to traffic. Cure Types B and C patches according to the manufacturer's recommendations.

256.09 Method of Measurement. The City will measure the quantity of Bonded Patching of Portland Cement Concrete Pavement, Type ___ by the number of square feet of the exposed surface of all patches, irrespective of the depth of the patch, repaired in the complete and accepted work. If the actual measured area of a patch is less than 2 square feet, the Engineer will increase each such measurement to 2 square feet.

256.10 Basis of Payment. The City will pay for accepted quantities at the contract price as follows:

Item	Unit	Description
256	Square Feet	Bonded Patching of Portland Cement Concrete Pavement, Type __

ITEM 257 DIAMOND GRINDING PORTLAND CEMENT CONCRETE PAVEMENT

257.01 Description
257.02 Equipment
257.03 Construction
257.04 Final Surface Finish
257.05 Method of Measurement
257.06 Basis of Payment

257.01 Description. This work consists of diamond grinding and texturing PCC pavement longitudinally to substantially eliminate joint and crack faulting and to restore proper riding characteristics to the pavement surface.

257.02 Equipment. Provide grinding equipment that is a power driven, self-propelled machine that is specifically designed to smooth and texture PCC pavement with diamond blades or diamond impregnated cylinder rings. Mount the blades or cylinder rings on an arbor head. Provide a grinding head at least 3 feet wide. Ensure the equipment is capable of grinding the surface in the longitudinal direction without causing spalls or other damage at cracks, joints and other locations. Ensure the equipment is capable of correcting the pavement profile and providing proper cross slope on the concrete pavement.

Provide equipment with an effective wheelbase of at least 12.0 feet; a set of pivoting tandem bogey wheels at the front of the machine and rear wheels that travel and track in the fresh cut pavement. Ensure the center of the grinding head is no further than 3.0 feet forward from the center of the back wheels. Ensure the equipment is of a shape and dimension that does not encroach on traffic movement outside of the work area.

257.03 Construction. The plans will designate the areas of pavement surfaces to be ground. Grinding of bridge decks, approach slabs, and roadway shoulders will not be required unless indicated on the plans or required to provide drainage. Perform grinding in a manner that eliminates crack or joint faults while providing positive lateral drainage by maintaining a constant cross-slope between grinding extremities in each lane. Transition auxiliary or ramp lane grinding as required from the mainline edge to provide positive drainage and an acceptable riding surface.

Ensure the operation results in pavement that conforms to the typical cross-section and the requirements specified for the final surface finish, however, it is the intention of this specification that the faulting at joints and cracks be eliminated and the overall riding characteristics be restored within the limits specified. To accomplish the smoothness required, grinding may not be required on 100 percent of the pavement surface.

During initial grinding operations, use the profiler to test the pavement surface as soon as the concrete has been ground full lane width. This initial testing is to aid the Contractor in evaluating the grinding methods and equipment being used. Subsequent to the initial testing, run daily profiles of each day's grinding the next working day.

Remove all grinding residue. Remove solid residue before it is blown by traffic action or wind. Do not allow residue to flow across lanes used by the traveling public or into gutters or drainage facilities.

257.04 Final Surface Finish. Produce a pavement surface that is true to grade with the ground area consisting of a longitudinal corduroy-type texture. Ensure the peaks of the ridges are approximately 1/16 inch higher than the grooves with 53 to 57 evenly spaced grooves per foot.

Provide the necessary traffic control and survey stationing for initial measurements or any subsequent measurements. Measure the entire length of pavement, event marking the profile runs such that the data can later be identified when the profile sensor(s) is within 1.0 foot of any bridge deck, pressure relief joint, approach slab, or pavement not included in the grinding area identified in the plans or established by the Engineer.

Ensure transverse joints and cracks are flush with adjacent surfaces. The Engineer will visually inspect transverse joints and cracks to ensure that adjacent surfaces are in the same plane. Adjacent sides of joints or cracks within 1/16 inch of each other will be considered flush. Ensure the transverse slope of the pavement is uniform to a degree that no depressions or misalignments of slope greater 1/4 inch in 12 feet are present. Use a straightedge placed perpendicular to the centerline to measure depressions and misalignments. Straightedge requirements do not apply outside of area ground.

257.05 Method of Measurement. The City will measure diamond grinding by the number of square yards of pavement ground and accepted. The quantity of diamond grinding will be determined by multiplying the width specified on the plan by the total length of the diamond ground surface.

257.06 Basis of Payment. Payment is full compensation for furnishing all labor, materials, tools, equipment and incidentals and for doing all work involved in grinding the existing surface, removing residue, cleaning the pavement, and testing with a profiler.

The City will pay for accepted quantities at the contract price as follows:

Item	Unit	Description
257	Square Yard	Diamond Grinding Portland Cement Concrete Pavement

ITEM 259 PERMANENT PAVEMENT REPLACEMENT

259.01 Description
259.02 General
259.03 Classification
259.04 Construction
259.05 Brick Pavements
259.06 Method of Measurement
259.07 Basis of Payment

259.01 Description. This work consists of removal and replacement of permanent street or driveway pavements as indicated in the plans or as directed by the Engineer. This item shall also be used for replacement of pavement damaged by the Contractor or its agents and pavement cuts for placing of conduits or other structures beneath a permanent pavement or asphalt replacement related to curb. Permanent pavement as herein used shall mean any hard surface type pavement including asphalt, PCC, brick, surface treated macadam and similar materials.

259.02 General. The Engineer will select the type of pavement replacement to be provided to most nearly duplicate the pavement removed. The pavement types to be provided are shown in 259.03. In the event of a conflict between the type of replacement shown on the plans and that selected by the Engineer, the Engineer's selection shall govern. With the approval of the Engineer, the Contractor may use alternative surfaces, bases, or both, at no additional cost to the City. Do not perform any repaving under this item without the Engineer's approval.

259.03 Classification. Based upon the Engineer's selection as described in 259.02, furnish one of the following pavement types:

Permanent Pavement Replacement (Standard Drawing No. 1441)
Type I - Asphalt
Type III - Brick
Type V - Concrete

Driveway Pavement Replacement (Standard Drawing No. 2160)
Type IIIA - Asphalt Driveways
Type IIIB - Concrete Driveways
Type IIIC - Gravel Driveways

259.04 Construction. Cut the edges vertical and trim to provide a straight line juncture between the existing and new pavement, containing no ragged edges. Finish concrete surfaces to match as nearly as possible the adjacent surfaces. Where the edge of the repair is less than 2 feet from the curb, remove and replace the wearing surface up to the curb.

259.05 Brick Pavements. This work shall consist of excavation of brick or concrete patches in brick pavements and replacement with TYPE III pavement according to 259.03.

A. Materials. Remove all salvageable bricks without unnecessary damage, and clean and store in a safe place for reuse. When excavations are performed on streets with historical bricks, any additional bricks needed to complete the repair shall be historical solid fireclay brick (4 x 8 x 4 inches). When excavations are performed on newer style roadway pavers, comply with Supplemental Specification 1524. Prior to starting, submit 3 samples of bricks that closely match the existing brick. The Engineer will review for color and texture only. Compliance with all other requirements is the responsibility of the Contractor.

B. Installation. Set brick in reasonably close conformity to the patterns of the existing brick pavement.

259.06 Method of Measurement. The City will measure street and driveway permanent pavement replacement by the volume in cubic yards actually placed except that in no case shall measurements extend beyond the limits of 1 foot exterior to the limiting lines shown for excavation on standard drawings, unless otherwise approved by the Engineer.

259.07 Basis of Payment. Payment is full compensation for furnishing all materials, labor, tools, equipment, and incidentals necessary to complete this work, including both surface and base construction and temporary pavement removal.

The City will pay for accepted quantities at the contract price as follows:

Item	Unit	Description
259	Cubic Yard	Permanent Pavement
259	Cubic Yard	Driveway Pavement Replacement, Type __

300 BASES

ITEM 301 ASPHALT CONCRETE BASE

301.01 Description
301.02 Composition
301.03 Mixing
301.04 Spreading and Finishing
301.05 Spreading and Surface Tolerances
301.06 Basis of Payment

301.01 Description. This work consists of constructing a base course of aggregate and asphalt binder, mixed in a central plant and spread and compacted on a prepared surface.

The requirements of Item 401 apply, except as modified by this specification.

301.02 Composition. Furnish aggregate for the mix that conforms to the following gradation:

Sieve Size	Total Percent Passing
2 inch	100
1 inch	75 to 100
1/2 inch	50 to 85
No. 4	25 to 60
No. 8	15 to 45
No. 16	10 to 35
No. 50	3 to 18
No. 200	1 to 7

Submit for the Laboratory's approval the desired percentage of the aggregate passing the No. 4 sieve and blend of individual components. The Contractor may use reclaimed asphalt concrete pavement according to 401.04. The Laboratory will establish the required binder content within a range of 4.7 to 7 percent. Do not make changes in these JMF values due to unsatisfactory results or other conditions except as authorized by the Laboratory. Obtain a new JMF approval for any desired change to an existing JMF.

301.03 Mixing. If using a batch plant, use screens with openings of sizes that result in a reasonably balanced separation of the dried and heated aggregate into a minimum of two bins.

301.04 Spreading and Finishing. Ensure that the maximum compacted depth of any one layer is 6 inches. Ensure that the temperature of the mixture when delivered to the paver is a minimum of 250°F if a hot mix asphalt and 230 °F if a warm mix asphalt according to 402.04. Ensure the temperature of the mixture is sufficient for the roller coverage to be effective in compacting the mixture.

301.05 Spreading and Surface Tolerances. Do not exceed 3/8 inch in surface variation from the testing edge of a 10-foot straightedge. If using Item 301 Asphalt Concrete Base as a subbase for a rigid pavement or base, do not exceed a variation of 1/4 inch.

Correct variations in excess of slope or surface tolerances by adding or removing material in a manner satisfactory to the Engineer. The Contractor may use asphalt concrete approved by the Engineer.

301.06 Basis of Payment. The City will pay for accepted quantities, complete in place, at the contract price as follows:

Item	Unit	Description
301	Cubic Yard	Asphalt Concrete Base

ITEM 302 ASPHALT CONCRETE BASE

302.01 Description
302.02 Composition
302.03 Mixing
302.04 Spreading and Finishing
302.05 Spreading and Surface Tolerances
302.06 Basis of Payment

302.01 Description. This work consists of constructing a base course of aggregate and asphalt binder, mixed in a central plant and spread and compacted on a prepared surface.

The requirements of Item 401 apply, except as modified by this specification.

302.02 Composition.

A. General. Furnish a mixture that conforms to the following gradation:

Sieve Size	Total Percent Passing
2 inch	100
1 1/2 inch	85 to 100
1 inch [1]	68 to 88
3/4 inch [1]	56 to 80
1/2 inch [1]	44 to 68
3/8 inch [1]	37 to 60
No. 4	22 to 45
No. 8	14 to 35
No. 16	8 to 25
No. 30	6 to 18
No. 50	4 to 13
No. 200	2 to 6

[1] Provide aggregate to retain a minimum of 7 percent of the material on each of these sieves. This requirement applies to the gradation of the JMF and the mix production according to Item 403.

In the design of the asphalt concrete base, the requirements of Item 441 apply, except as follows:

The Contractor may use reclaimed asphalt concrete pavement according to 401.04. Should problems with proper coating or other material issues related to the use of reclaimed asphalt concrete pavement be evident, the Laboratory may restrict the allowable percentage of reclaimed asphalt concrete pavement to the reduced limits shown in tables 401.04-1 and 401.04-2. In this case, the Laboratory will adjust the virgin binder content.

Add hydrated lime in the dry form at a rate of 0.75 percent by the dry weight of aggregate for asphalt concrete base, if antistrip additive is required and hydrated lime is used.

Design the asphalt concrete base to yield 4.0 percent air voids and the following properties:

Property	Acceptable Range of Values	
	Minimum	Maximum
Binder Content, %	[Note 1]	6.0 [Total]
Stability, lb, 70 blow	3000	--
Flow, 0.25 mm, 70 blow	--	28
Voids in Mineral Aggregate %	12.0	--

Note 1: See tables in 401.04

Use equipment that meets the requirements of a Level 3 laboratory as specified in City Supplement 1041. Ensure that the following equipment is designed and manufactured according to ASTM D5581 to prepare and test a Marshall specimen with a 6.0-inch diameter and a 3.75 ± 0.05 inch height:

1. Specimen mold assembly.
2. Specimen extractor.
3. Compaction Hammer.
4. Compaction pedestal specimen mold holder.
5. Marshall test apparatus.

Produce batches of asphalt concrete base in the amount that will result in a compacted specimen 3.75 ± 0.05 inch in height. This amount is about 4050 grams.

B. Compaction of Specimens. Fill the mold with asphalt concrete base by placing approximately one-half of the batch in the mold and spading it vigorously with a heated spatula or trowel 15 times around the perimeter and ten times over the interior. Place the second half of the batch in the mold and spade the mixture in the same manner.

Compact the specimen on both sides with 70 blows.

C. Stability Correlation Ratios. Convert measured stability values for specimens that depart from the standard 3.75-inch thickness to an equivalent 3.75-inch value by multiplying the stability value by the appropriate correlation ratio as follows:

Approximate Thickness of Specimen, inches	Correlation Ratio
3 -1/2	1.12
3 -9/16	1.09
3 -5/8	1.06
3 -11/16	1.03
3 -3/4	1.00
3 -13/16	0.97
3 -7/8	0.95
3 -15/16	0.92
4	0.90

302.03 Mixing. Conform to the requirements of 301.03.

302.04 Spreading and Finishing. Ensure that the compacted depth of any one layer is a minimum of 4 inches and a maximum of 7.75 inches. If the plan thickness is 7.0-7.75 inches and Laboratory confirms the JMF and mixture production has 95% passing the 1.50 inch sieve, the 302 may be placed in two lifts if requested by the Contractor. One lift of plan thickness will be required if top size aggregate dragging occurs. Ensure that the temperature of the mixture when delivered to the paver is a minimum of 250 °F if a hot mix asphalt and 230 °F if a warm mix asphalt according to 402.04. Ensure the temperature of the mixture is sufficient for the roller coverage to be effective in compacting the mixture.

302.05 Spreading and Surface Tolerances. Conform to the requirements of 301.05.

302.06 Basis of Payment. The City will pay for accepted quantities, complete in place, at the contract price as follows:

Item	Unit	Description
302	Cubic Yard	Asphalt Concrete Base

ITEM 304 AGGREGATE BASE

304.01 Description
304.02 Materials
304.03 Before Spreading
304.04 Spreading
304.05 Compaction
304.06 Finished Surface
304.07 Method of Measurement
304.08 Basis of Payment

304.01 Description. This work consists of furnishing, placing, and compacting one or more courses of aggregate on a prepared surface, including furnishing and incorporating all water required for compaction.

304.02 Materials. Furnish materials conforming to 703.17.

304.03 Before Spreading. The Engineer will sample the Contractor's stockpile to determine the initial moisture content to be used for compaction. The Engineer will develop a moisture-density curve according to Supplemental Specification 1501 to determine the optimum moisture content.

Use material that has reasonably uniform moisture content. Ensure the moisture content is not less than 2 percent below the optimum moisture content before spreading. Add water to the stockpile if necessary to meet this moisture requirement.

Handle the material in a manner to minimize segregation. If segregation occurs, thoroughly mix or regrade the stockpile.

304.04 Spreading. Spread the material on the prepared surface. Do not use frozen material and do not spread on frozen surfaces.

Do not exceed a compacted lift thickness of 8 inches when using vibratory rollers with effective weights greater than 12 tons. Do not exceed a compacted lift thickness of 6 inches when using vibratory rollers with effective weights from 10 to 12 tons. Do not exceed a maximum compacted lift thickness of 4 inches when these vibratory rollers are not used. The effective weight of a vibratory roller is the weight plus the centrifugal force from vibration. Submit documentation from the manufacturer that shows the vibratory roller meets the minimum effective weight requirements.

Place the material in two or more approximately equal lifts when the specified compacted thickness exceeds the maximum allowed.

Place the material with self-propelled spreading machines capable of placing the material true to line and grade. Spreading machines such as spreader boxes or pavers are allowed. Do not use graders or dozers without spreader boxes to spread the material except for areas described in the next paragraph. Spread the material such that it minimizes segregation and requires minimal blading or manipulation. The City may perform in-place gradation testing in areas that are visually segregated according to City Supplement 1090 as directed by the Engineer.

The Contractor may use hand-placing methods, dozers or graders when the total area of the material is 2,000 square yards or less or in small areas where self-propelled spreading machines are impractical. Small areas include lane widths less than 12 feet or lengths less than 1,000 feet. The City will not take in-place gradation tests in these small areas.

The City may test for in-place gradation after spreading but before compaction testing according to City Supplement 1090 as directed by the Engineer.

304.05 Compaction. The City will measure compaction according to Supplemental Specification 1501.

Add water or dry the material to bring it to within 2 percent of the optimum moisture content before compacting. Maintain the moisture content within this range during all compaction operations. The Engineer will determine the percentage of moisture to apply or to be dried from the material. Uniformly apply the water or dry the material throughout the lift and in a manner that does not soften or disturb the lower courses. Reduce the moisture content if the material becomes unstable during the compaction operation.

Compact each lift of material immediately after spreading. Use rollers that correspond with the lift thickness as described in 304.04. The Contractor may use lighter rollers or vibratory equipment in small areas as specified in 304.04 or when heavier rollers are not practical. Approved compaction equipment may consist of vibratory rollers, static rollers, or vibratory equipment.

At the beginning of the compaction operation, construct a test section. The Engineer will determine the density requirements according to Supplemental Specification 1501. Use a minimum compactive effort of eight passes to construct the test section. Use and adjust the vibration on the vibratory rollers to maximize the density and stability. Construct a new test section when the material changes or when the supporting materials change appreciably.

The Engineer will use 98 percent of the test section maximum dry density for acceptance of the production material. Use at least the same number of passes and compactive effort used to obtain the test section maximum dry density for the production material. At a minimum, use eight passes in the production area. The Engineer may reduce the minimum passes if the passes are detrimental to compaction.

The Engineer may check the production material density before or after the finishing operations.

Maintain the surface of each lift during the compaction operations in such a manner that the surface texture is reasonably uniform and the material is firmly keyed.

Cover the aggregate base with the next layer of pavement before the end of the construction season. If the aggregate base is not covered up, then assume all liability for contamination of, damage to and instability of the base, subgrade and underdrains.

Provide drainage and maintain the material according to 203.04.A.

304.06 Finished Surface. Ensure that the finished surface does not vary more than 3/8 inch from a 10-foot straightedge parallel to the centerline or more than 1/2 inch from a template conforming to the required cross-section. Furnish straightedges, templates, or other devices satisfactory to the Engineer, and check the surface for conformance with these requirements.

Do not construct the aggregate base at a consistent depth below the required minimum compacted depth thickness. When the depth is found to be less than the required depth, provide the Engineer with a written corrective action plan for approval.

304.07 Method of Measurement. The City will measure Aggregate Base by the number of cubic yards computed from the profile grade and typical sections, compacted in place.

Where variable depth is specified, the City will measure the number of cubic yards of aggregate base by converting from weight using the following conversion factors:

TABLE 304.07-1

Material	Conversion Factor
Crushed stone	4000 lb/yd^3
Crushed gravel	4000 lb/yd^3
Crushed slag [1]	
less than 90 lb/ft^3	3600 lb/yd^3
90 to 100 lb/ft^3	4000 lb/yd^3
more than 100 lb/ft^3	4500 lb/yd^3
Granulated slag	2800 lb/yd^3

[1] Based on average dry rodded weight of standard size of slag aggregates on record at the Laboratory. The conversion factors listed are the long gradation weights. These numbers are based on the dry rodded weights of No. 67, 57, or 8 gradation. The City will determine slag weights based on weights obtained from the original source.

The City -may verify that the moisture content of the delivered material is less than 2 percent above saturated surface dry (SSD) as directed by the Engineer. If the moisture content is greater than 2 percent above SSD, then the City will calculate the number of cubic yards based on the dry density and dry weight.

The City may determine the pounds per cubic yard for aggregate mixtures by using 100 percent of the test section maximum dry density obtained in 304.05 as directed by the Engineer.

304.08 Basis of Payment. The City will pay for accepted quantities at the contract price as follows:

Item	Unit	Description
304	Cubic Yard	Aggregate Base

ITEM 305 PORTLAND CEMENT CONCRETE BASE

305.01 Description
305.02 Construction
305.03 Method of Measurement
305.04 Basis of Payment

305.01 Description. This work consists of constructing a portland cement concrete base on a prepared surface.

305.02 Construction. The requirements of Item 451 apply, except as follows.

Do not comply with the requirements of 451.08.

Load transfer devices are not required.

Do not place construction joints within 6 feet of another parallel joint.

Modify the curing membrane application rate specified in 451.11 to 200 square feet per gallon of treated pavement surface.

Produce a final surface with a uniform, gritty, longitudinal, or transverse texture using a broom drag in either direction.

Ensure that pavement surface variations do not exceed 1/4 inch in 10 feet.

Impressing station numbers into the plastic concrete as specified in 451.10 is not required.

305.03 Method of Measurement. The City will measure Concrete Base by the number of square yards completed and accepted in place. The width equals the base width shown on the typical cross-section of the plans plus additional widening as the Engineer directs in writing. The City will field measure the length along the centerline of each roadway or ramp.

305.04 Basis of Payment. For base found deficient in thickness, the City will pay a reduced price according to 451.18.A and table 451.19-1.

The City will not make additional payment over the Contract unit price for any base with an average thickness in excess of that shown on the plans.

For base found deficient in strength, the City will pay a reduced price according to 451.18.B and table 451.19-2.

The City will pay for accepted quantities at the contract price as follows.

Item	Unit	Description
305	Square Yard	___inch Concrete Base

ITEM 306 PORTLAND CEMENT CONCRETE BASE – RESIDENTIAL

306.01 Description
306.02 Method of Measurement
306.03 Basis of Payment

306.01 Description. This work consists of constructing a PCC base on a prepared subgrade or base course. This work shall conform to the requirements of Item 305 and Item 451 except that:

1. For concrete proportioning, meet the requirements of Item 499, Concrete, Class COC 7 or COC MS.
2. Conform to the opening-to-traffic requirements as specified in 451.16 except that the split tensile strength shall be 350 pounds per square inch, as tested per ASTM C496.

306.02 Method of Measurement. The City will measure Concrete Base – Residential according to 305.03.

306.03 Basis of Payment. The City will pay for accepted quantities at the contract price according to 305.04 and as follows.

Item	Unit	Description
306	Square Yard	___inch Concrete Base - Residential

ITEM 307 ROLLER COMPACTED CONCRETE BASE (RCC)

307.01 Description
307.02 Materials
307.03 Mix Design
307.04 Contractor Certification
307.05 Test Strip

307.06 Equipment
307.07 Construction Requirements
307.08 Joints
307.09 Quality Control and Assurance
307.10 Opening to Traffic
307.11 Pavement Thickness and Strength
307.12 Price Adjustments
307.13 Basis of Payment

307.01 Description. This work consists of the production and construction of Roller Compacted Concrete Base (RCC) for City streets. In addition to this specification, Items 305, 306, 451, and 452 apply.

307.02 Materials. All materials shall be from approved sources as documented on the "Approved Materials List" on file in the Laboratory.

Portland cement shall conform to 701.01, 701.02, 701.04, and 701.05.

Fly Ash shall conform to 701.13.

Ground Granulated Blast Furnace Slag (GGBFS) shall conform to 701.11.

Chemical admixtures shall conform to 705.10 and 705.12.

Curing Compounds shall conform to 705.07.

Fine and course aggregates shall meet the requirements of 703.02. The aggregates shall be well graded to conform to the following composite gradation.

Sieve Size	Percent Passing
1"	100
¾"	95 – 100
½"	70 – 90
3/8"	60 – 85
#4	40 – 70
#16	20 – 40
#100	5 – 20
#200	2 – 8

Mixing water shall be clean, potable and free from oil, acid and strong alkalis or organics.

307.03 Mix Design. The Contractor/Supplier shall develop an RCC mixture proportioned in accordance with this specification and procedures discussed in ACI 325.10R-95 (Re-approved 2001) "Report on Roller-Compacted Concrete Pavements" sections 4.2, 4.3, and 4.4. Once the mix has been designed, certified test data shall be submitted to the City from a recognized testing laboratory that shows the proposed mix design will meet the following requirements.

A. Roller Compacted Concrete Base

Compressive Strength, Cores: 4000 psi @ 28 days.
Splitting Tensile Strength, Cores: 400 psi @ 5 days.

The minimum Portland cement content shall be 350 pounds per C.Y.

B. Roller Compacted Concrete Base – Residential

Compressive Strength, Cores: 3000 psi @ 28 days.
Splitting Tensile Strength, Cores: 300 psi @ 5 days.

The minimum Portland cement content shall be 300 pounds per C.Y.

Submit Certifications for aggregate source quality and sizing, Portland cement, and supplementary cementitious materials as required by the specification.

Secondary Cementations material shall not be considered as a substitute for any deficiency in the #100 sieve in section.

Strength properties shall be based on field extracted cores.

The Contractor's Independent Testing Laboratory will develop a moisture/density relationship of the actual job materials in accordance with ASTM D 1557. Optimum moisture content and maximum wet densities shall be established and copies of the moisture-density curves shall be provided to the City with the mix design submittal.

The proposed mix design shall be submitted to the City for approval at the beginning of each year. A list of approved mix designs will be kept on file in the Laboratory.

Only use mix designs accepted by the City and issued a JMF number.

307.04 Contractor Certification.

RCC Contractors must perform a test strip per 307.05 for certification to place RCC on City of Columbus projects. Upon successful completion of the test strip, the City will certify the Contractor to place RCC on City projects. A list of approved Contractors will be maintained on the City's website.

For any compacted lift thickness greater than 10", a separate test strip of the planned thickness must be performed to certify the Contractor's ability to meet these specifications. Separate Contractor certifications will be issued by the City for compacted thicknesses greater than 10".

The Contractor shall not commence placement of RCC until all testing has been completed on the test strip and the City has verified the results are acceptable.

Material changes in the Contractor's operations or failure to comply with the specifications will be grounds for rescission of certification at the discretion of the City.

307.05 Test Strip. The Contractor shall construct a test strip with at least 100 tons of RCC at a depth of approximately 10" with the paver(s) and mix(es) proposed for use. The test strip will be used to certify the Contractor's ability to place RCC on City projects. The test strip shall be constructed at a location chosen by the Contractor at least 30 days prior to the start of any paving operations. The Contractor must demonstrate the ability to achieve a smooth, hard, uniform surface free of excessive tears, ridges, spalls and loose material. The Contractor must also be able to consistently achieve 90% of the maximum wet density directly out of the paver and 98% of the maximum wet density after final rolling.

During construction of the test strip, the Contractor shall establish an optimum rolling pattern and procedure for obtaining a density of not less than 98% of the maximum wet density. After completion of the test strip, cores will be extracted by the City to verify mix compliance. During the trial placement, the City's testing personnel shall calibrate their nuclear density gauges in accordance with ASTM C 1040, with a sample of the test strip mix. Moisture readings of the gauge shall be calibrated using oven dry samples of the plant-mixed RCC.

307.06 Equipment.

A. Mixing Plants: Mixing plants shall be of a design that can produce an RCC pavement mixture of the proportions defined in the approved mix design and within the specified tolerances in ASTM C 94 and ASTM C 685. The mixing plant may be a Central-Mix Drum or a Stationary Continuous-Mixing Twin-Shaft Pug Mill mixer. The plant shall have a minimum manufacturer's rated capacity of 200 tons per hour.

B. Pavers: RCC shall be placed with a high-density asphalt paver subject to approval by the Engineer. The paver shall be capable of placing the RCC at a minimum of 90% of the maximum wet density in accordance with 307.07.E. The paver shall be of suitable weight and stability to spread and finish the RCC material, without segregation to the required thickness, smoothness, cross-section and grade. Work in areas inaccessible to paving machines shall be performed according to 307.07.F.

C. Vibratory Rollers: Vibratory rollers shall be self-propelled, double drum, steel wheel vibratory rollers having a static weight of at least 10 tons. Each roller drum shall be equipped with a properly operating scraper and brush. The rollers shall transmit a dynamic impact to the surface through smooth steel drums by means of revolving weights, eccentric shafts or other equivalent methods. The roller drum shall be between 4 and 5-1/2 foot in diameter and 5-1/2 to 8 feet in width.

Finish rollers shall be self-propelled, double drum, steel wheel rollers having a static weight of between 3 and 10 tons. Each drum shall be equipped with a properly operating scraper and brush. A single drum vibrator roller with a vulcanized rubber coating may be utilized for finish rolling, at the approval of the Engineer.

D. Dump Trucks: Dump Truck boxes shall be kept free of contaminants while hauling any RCC and shall have protective covers properly secured until discharge into the paver.

307.07 Construction Requirements.

A. Preparation of Sub-grade/Sub-base: Prepare the entire sub-grade according to Item 204 prior to placing any RCC. If required, construct a granular base according to Item 304. Test roll the entire subgrade according to 204.061, except that the maximum allowable rutting or deflection shall be 1/2-inch. This will provide a proper base to place and compact the RCC.

Moisten the surface of the sub-grade or base without creating mud or ponding water, to minimize absorption of water from RCC mix to be deposited.

B. Transportation: Transport the RCC mixture to the site in dump trucks which meet the requirements of 307.06.D. The trucks shall dump directly into the hopper of the paver. Hauling over the freshly placed RCC will not be permitted except in multi-lift operations to the extent required to dump the fresh RCC into the paver.

C. Placing RCC: Place RCC to the thickness, grade, and lines indicated in the plans. Achieve a minimum of 90% of the maximum wet density out of the paver and 98% of the maximum wet density after final rolling. No compacted lift thickness shall be in excess of ten (10) inches or less than four (4) inches for single or multiple-lift applications unless approved by the City. Co-ordinate RCC delivery so the mix can be spread and rolled within the specified time limit and to ensure uniform progress of the paver until the paving operation is complete. The time between mixing and compacting shall not exceed ninety (90) minutes, for all RCC placed, provided the temperature of the RCC does not exceed 90º F.

Operate the paver in a manner that will prevent segregation and will produce a smooth continuous surface without tearing, pulling or shoving. If segregation occurs, suspend the paving operation until the cause is determined and corrected. Areas of segregated RCC shall be removed and replaced as specified in 307.11.

Scarify all areas that require broadcasting or fanning of RCC. The surface must be scarified at least one inch deep prior to broadcasting fresh RCC over the top. Broadcasting must be completed in the allotted time within these specifications.

D. For multiple-lift placement, the total pavement thickness shall be as specified on the plans. The second lift must be placed within sixty (60) minutes of the completion of the first lift. If more than sixty (60) minutes has elapsed, the interface between the first and second lifts shall be considered a cold joint and shall be prepared in accordance with 307.08.D. Placement of the second lift must be delayed until the first lift has attained design strength as specified in 307.03.

E. Compaction: Achieve at least 90% of the maximum wet density, as determined in the laboratory according to ASTM D 1557, directly out of the paver and at least 98% of the maximum wet density after final rolling. The Contractor shall begin compaction operations within fifteen (15) minutes after spreading of the RCC mix. Any additional delay will result in the coring of the affected area at the Contractor's expense to ensure that it meets the requirements of this specification.

F. Rolling: The Contractor shall establish a rolling pattern that will achieve the required density with a minimum number of roller passes. During vibratory compaction, the roller shall not be started, stopped, or left standing in vibratory mode. Stagger the stopping point of successive rolling passes to avoid forming depressions on the surface.

The Contractor shall continually check the RCC surface while still plastic to ensure surface and grade tolerances are met. Immediately correct excessive variations in accordance with the spreading requirements. The Contractor shall remove any roller marks on the surface using a steel drum roller in static mode. Each lane edge shall be constructed with a face within 15-degrees of vertical.

The Contractor shall spread RCC mix by hand in areas not accessible by the paver and compact to the requirements of 307.07.E.

G. Curing: Keep the RCC surface continuously moist by water, fog spray, wet burlap, an approved membrane-forming curing compound applied at 1.5 times the rate specified by the manufacturer, or polyethylene sheeting for a period of five (5) days or until the core strengths have meet the requirements of 307.03.

H. Weather Limitation: RCC shall not be placed on any surface containing frost or frozen material. RCC shall only be placed when the ambient temperature is a minimum of 32F and rising, unless the procedures set forth in 451.071 are strictly enforced. During periods of hot weather or windy conditions, special precautions shall be taken to minimize moisture loss due to evaporation.

Do not place RCC when rain is imminent. If rain occurs during placement of RCC, cease all operation.

307.08 Joints.

A. Fresh Vertical Joint: A vertical joint shall be considered a fresh joint when an adjacent RCC lane is placed within 90 minutes of placing the previous lane. The Contractor shall ensure that the contact face is moist and not segregated. Before rolling, the vertical joint surface should be hand-finish as necessary immediately behind the paver to produce a tight surface. When placing RCC with a fresh longitudinal joint, leave the outer 12 to 18 inches of the paving lane uncompacted during the initial rolling operation. The uncompacted edge is then used to set the height of the paver screed for paving the adjacent lane. After the adjacent lane is placed, the joint is compacted by centering the roller drum over the joint and compacting adjacent lane edges simultaneously. Roll extra passes as necessary to achieve the required density and smoothness in the joint area.

B. Cold Vertical Joint: A cold vertical joint is made when either side of the joint is not compacted within 90 minutes of plant mixing. Saw cut the edge of the previous lane back to sound RCC (minimum 6 inches) to form a vertical face prior to placing the next pass. Trimming by grader blade is permitted, if done prior to the end of the workday. Prior to placing fresh RCC mixture against a compacted cold vertical joint, the joint shall be thoroughly cleaned of any loose or foreign material. The vertical joint face shall be wetted and a moist condition immediately prior to placement of the adjacent lane.

C. Fresh Horizontal Joint: For multiple-lift applications, a horizontal joint is considered a fresh joint when a subsequent RCC lift is placed within sixty (60) minutes of placing the previous lift. The surface of the lower lift shall be kept clean and continually moistening the surface prior to placement of the subsequent lift.

D. Cold Horizontal Joint: For multiple-lift applications, a horizontal joint is considered a cold joint when the placing of the subsequent RCC lift is delayed by more than sixty (60) minutes of placing the previous lift. Immediately prior to placing the second lift of RCC, a cement/sand slurry or grout shall be applied to the contact surface of the first lift. The Contractor shall delay placing the second lift of RCC until the first lift attains design tensile strength as specified in 307.03.

E. Contraction Joints: Transverse and Longitudinal contraction joints shall be made as soon as possible after placement of RCC without damaging the pavement, according to City of Columbus Standard Drawing 2170 or as approved by the Engineer, except that transverse joints shall be spaced at a maximum of 30 foot intervals, or at intervals directed by the Engineer. All pavements shall have at least one center longitudinal contraction joint.

307.09 Quality Control and Assurance. The Contractor shall maintain equipment and qualified personnel required to monitor and ensure the various properties of the RCC produced meet the specifications. These properties shall be maintained within the limits of this specification throughout production. The Contractor shall notify the Engineer a minimum of 24 hours prior to start of RCC paving.

Testing at the plant and the paving site is the responsibility of the Contractor and shall be performed by a private Independent Testing Laboratory approved by the City. The Contractor and Supplier shall provide safe and convenient access, acceptable to the Engineer, for the inspection and sampling of the RCC and constituent materials, at both the production plant and the paving site and shall cooperate in the inspection and sampling process at all times.

A. During Placement: The Contractor shall ensure quality control at the plant, by controlling materials, obtaining test samples and ensuring segregation is not occurring while loading haul trucks. The Contractor, in cooperation with the Contractor's Independent Testing Laboratory, shall ensure that compaction and grade specifications are met and time limits are adhered to.

B. Field Density: The Laboratory shall perform density testing of the RCC in accordance with ASTM C 1040, direct transmission mode, directly behind the paver. Only wet density shall be used for evaluation. At least five (5) tests shall be performed at the back of the paver and after final compaction for each 250 cubic yards placed. The required density shall be as specified in 307.07.E out of the back of the paver and after final rolling. The Contractor shall be responsible for verifying required densities are achieved by the paver and after final rolling.

If density test results do not meet the requirements of 307.07.E, the Contractor shall determine the source of the problem and take immediate steps to correct the problem. If the problem cannot be resolved to the satisfaction of the Engineer, placement shall be suspended.

307.10 Opening to Traffic. The RCC pavement may be opened to traffic or asphalt surfaced as specified on the plans a minimum of five (5) days after placement or once the Splitting Tensile strength requirements of 307.03 have been met.

307.11 Pavement Thickness and Strength. After placement, the Laboratory shall core nine (9) four-inch diameter cylindrical specimens at nine randomly spaced locations from each Pavement Unit as defined in 451.18. Length measurements of the cores and compressive strength testing shall be in accordance with ASTM C 42. Splitting tensile testing shall be in accordance with ASTM C 496.

If any core shows a deficiency in thickness of more than a 1/2 inch to one inch, or a compressive strength between 85% to 94.9% of the compressive strength mix design cited above, determine the extent limits of deficiency per 451.18. Apply price adjustments per 307.12.

If any core shows a deficiency in thickness of more than 1 inch or compressive strength less than 85% of the specified compressive strength, determine the extent limits of deficiency per 451.18. Remove and replace those areas greater than 1 inch deficient in thickness and/or less than 85% of the specified compressive strength per 307.11.

Core testing shall be conducted as follows:

Thickness Verification: All cores shall be measured for thickness verification.

Compressive Strength Testing: Six (6) of the cores obtained for thickness verification will be tested for compressive strength at 28 days.

Splitting Tensile Strength: Three (3) of the cores obtained for thickness verification will be tested for splitting tensile strength at five (5) days.

Remedial Actions: Correct deficiencies while RCC is still plastic; otherwise do repairs after five (5) days. After five (5) days, the RCC shall be removed by saw cutting full depth before removal. Replace the RCC utilizing a Cast-in-Place concrete meeting the requirements of Item 499; Class COC-1 or COC MS Concrete as directed by the Engineer. The new concrete shall be doweled into the existing RCC utilizing epoxy coated reinforcing bars according to 451.08.

Any RCC pavement found to be of unacceptable thickness, or deficient in any testing done in accordance with this specification, shall be subject to removal and replacement by the Contractor, at no cost to the City, including removal and replacement of any intermediate and surface asphalt courses.

Grind off high surface variations to a finish acceptable to the Engineer.

Filling of low areas with fresh RCC is not permitted.

If asphalt surfacing is specified, low areas accepted by the Engineer shall be made up with additional asphalt material without extra payment. All repairs are subject to the Engineer's approval.

307.12 Price Adjustments.

A. Thickness Deficiencies: Based on the pavement average thickness, payment will be made as specified in Table 307.12-1.

TABLE 307.12-1 PAVEMENT THICKNESS DEFICIENCY

Deficiency in Thickness as Determined by Cores	Proportional Part of Contract Price to be Paid
0.0 to 0.2 inch	100 percent
0.3 to 0.5 inch	$Ratio\ \left[\frac{PAT}{PST}\right]^6$
0.6 to 1.0 inch	$Ratio\ \left[\frac{DZA}{PST}\right]^6$
Greater than 1.0 inch+	Remove and replace

PAT = Project Average Thickness
PST = Plan Specified Thickness
DZA = Deficient Zone Average

B. Compressive Strength Deficiency: Where the average compressive strength of a pavement unit, as defined in 307.11, is less than the specified compressive strength, but greater than or equal to 85% of the specified compressive strength, payment will be made according to Table 307.12-2 below.

TABLE 307.12-2

Percent of Mix Design Strength	Payment Deduction Factor
95%- 100%	0%
90% - 95%	10%
85% - 90%	20%
Less than 85%	Remove and replace

The Engineer will determine whether deficient pavement areas from 0.6 up to 1 inch in thickness and/or 85% to 90% of the design compressive strength will be allowed to remain in place at the reduced price or must be removed and replaced.

In the case of a pavement area having deficiencies in thickness and strength, the greater of the two deductions shall be applied to the payment for this work.

307.13 Basis of Payment.

A. The accepted quantities of RCC pavement will be paid for at the contract unit price per square yard, which price and payment shall be full compensation for furnishing and placing all materials including reinforcing steel, dowels, and joint materials. The City will pay a reduced price, according to 307.12, for RCC pavement found deficient in thickness and/or strength.

B. No additional payment over the unit contract bid price will be made for any pavement which has an average thickness in excess of that shown on the plans.

C. The City will pay for accepted quantities, complete in place, at the contract price as follows:

Item	Unit	Description
307	Square Yard	___ inch Roller Compacted Concrete Base
307	Square Yard	___ inch Roller Compacted Concrete Base - Residential

ITEM 320 RUBBLIZE AND ROLL

320.01 Description
320.02 Materials
320.03 Equipment
320.04 Construction Details
320.05 Method of Measurement
320.06 Basis of Payment

320.01 Description. This work consists of rubblizing and rolling reinforced concrete pavement before placing an asphalt concrete pavement.

320.02 Materials. Furnish filler aggregate conforming to Item 304.

320.03 Equipment. Use a self-contained and self-propelled unit of either the resonant frequency type or the multiple head breaker type for rubblizing the concrete pavement.

If using a resonant frequency unit, ensure that it is capable of producing low amplitude, 2000-pound-force blows at a rate of not less than 44 blows per second.

If using a multiple head breaker unit, ensure that it has the capability of rubblizing the full 12-foot lane width in a single pass. Ensure the breaking head consists of 12 to 16 hammers, each weighing 1000 to 1500 pounds). Attach each hammer to a hydraulic lift cylinder that operates as an independent unit, develops 2000 to 12,000 foot-pounds of energy depending on lift height selected, cycles at a rate of 30 to 35 impacts per minute, and has a maximum lift height of 60 inches.

Use a vibratory steel wheel roller having a total weight of not less than 10 tons.

320.04 Construction Details. Make a full depth saw cut or cut load transfer devices at joints on ramps or mainline where the rubblizing abuts concrete pavement or approach slabs that are to remain in place permanently or temporarily for maintenance of traffic.

Before the rubblizing operations begin, the Engineer will designate a test section. Rubblize the test section according to this specification. After rubblizing, excavate a test pit, where the Engineer designates, to check for proper particle size throughout the thickness of the concrete. Fill in the test pit using the excavated material and additional filler aggregate as necessary. Compact the test pit as part of the rolling operation. Excavate at least one test pit, at the location designated by the Engineer, for each production day or every 7040 square yards, whichever is greater.

Adjust the rubblizing procedure to maintain the proper particle sizes. Control the operating speed of the rubblizing equipment such that: 75% of the rubblized particles above the reinforcing steel are reduced to 3 inches in their largest dimension, 90% of the rubblized particles below the reinforcing steel do not exceed 9 inches in their largest dimension, and no particles exceed 12 inches in their largest dimension.

Before placing the initial asphalt concrete course, compact the rubblized pavement with two passes of the vibratory roller. Operate the roller in the vibratory mode and at a speed not to exceed 6 feet per second.

Leave steel reinforcement in place in the rubblized pavement. However, cut off any exposed steel reinforcement below the surface and remove it from the site.

Fill depressions 1 inch or greater in depth compared to the immediate surrounding area resulting from the rubblizing, the compactive effort, or the steel reinforcement removal, with the filler aggregate. Strike off excess aggregate level with the surrounding area. Compact filled depressions with the same roller and compactive effort previously described.

Do not allow traffic on the rubblized pavement before the asphalt concrete base and intermediate courses are in place.

Do not allow more than 48 hours to elapse between rubblizing the pavement and placing the initial asphalt concrete course. However, in the event of rain, the Engineer may waive this time limitation to allow sufficient time for the rubblized pavement to dry to the Engineer's satisfaction. If the Engineer waives the time limitation, cease rubblizing the pavement until the Engineer allows paving to resume.

320.05 Method of Measurement. The City will measure Rubblize and Roll by the number of square yards. The Engineer will use the width of the concrete pavement prior to rubblizing and will measure the length along the centerline of each roadway or ramp.

The City will measure the Filler Aggregate by the number of cubic yards furnished, placed, and compacted.

320.06 Basis of Payment. The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
320	Square Yard	Rubblize and Roll
320	Cubic Yard	Filler Aggregate

ITEM 321 CRACKING AND SEATING NON-REINFORCED CONCRETE PAVEMENT

321.01 Description
321.02 Equipment
321.03 Construction Details
321.04 Method of Measurement
321.05 Basis of Payment

321.01 Description. This work consists of cracking and seating non-reinforced concrete pavement or concrete base before placing an asphalt concrete pavement.

321.02 Equipment. Use devices for cracking the concrete capable of producing the desired crack pattern without extensive spalling or excessive shattering. Extensive spalling is spalling over 1 1/4 inches in depth. Do not use whiphammers.

Use watering equipment capable of wetting the cracked surface uniformly to reveal the crack pattern.

Use a 50-ton pneumatic tire roller conforming to the requirements of Item 204 for seating the cracked concrete slabs. Use pneumatic tire towing equipment capable of moving the roller forward and backward along predetermined lines.

321.03 Construction Details. Demonstrate, to the Engineer's satisfaction, the ability of the selected equipment and procedures to produce cracking of acceptable quality by cracking at least three, but no more than five, concrete slabs. When cracking the test slabs, furnish and apply water to dampen the cracked concrete to enhance visual determination of the cracking pattern. In addition to 107.07, provide positive provision to contain any flying debris during cracking operations.

Crack concrete into nominal 4 × 4-foot segments. In the event panels are already cracked into segments, crack these segments further into nominally equal-sized square or rectangular pieces having longitudinal and transverse dimensions not more than 5 feet and not less than 3 feet, wherever feasible. Do not allow the cracking equipment to impact the slabs within 1 foot of another break line, joint, or the edge of the concrete.

Furnish and apply water to a check section of three to five slabs at least once each day to verify that a satisfactory crack pattern is being maintained. Make adjustments to the energy or striking pattern when the Engineer deems it necessary, based on the check sections.

Roll the cracked concrete until the concrete pieces are firmly seated. Perform rolling with at least two coverages as specified in Item 204. The Engineer will determine the maximum number of coverages of the roller on the test sections to ensure seating without damage to the concrete.

Before placing the asphalt concrete, remove all loose pieces of broken concrete that are not firmly seated. Repair all voids, such as spalls, removed loose pieces, joints, or cracks that, in the Engineer's opinion, will make uniform compaction of the first asphalt concrete course difficult. Repair voids by applying Item 407 tack coat, filling with asphalt concrete, and compacting as directed by the Engineer.

Do not allow traffic on the cracked concrete before the asphalt concrete base and intermediate courses are in place.

321.04 Method of Measurement. The Engineer will measure the area of non-reinforced concrete pavement or concrete base satisfactorily cracked and seated in square yards. The Engineer will use the width of the concrete pavement prior to cracking and will measure the length along the centerline of each roadway or ramp.

321.05 Basis of Payment. Include the cost of all crack pattern test and check sections including water; and for repairing of joint, cracks, spalls, and voids in the contract unit price for Cracking and Seating Non-Reinforced Concrete Pavement.

The City will pay for the accepted quantities at the contract price as follows.

Item	Unit	Description
321	Square Yard	Cracking and Seating Non-Reinforced Concrete Pavement

400 FLEXIBLE PAVEMENT

ITEM 401 ASPHALT CONCRETE PAVEMENTS—GENERAL

401.01 Description
401.02 Mix Design and Quality Control
401.03 Materials
401.04 Reclaimed Asphalt Concrete Pavement
401.05 Mixing Plants
401.06 Weather Limitations
401.07 Notification
401.08 Asphalt Binder
401.09 Aggregate Preparation
401.10 Mixing
401.11 Hauling
401.12 Spreading Equipment
401.13 Rollers
401.14 Conditioning Existing Surface
401.15 Spreading, Finishing and Night Work
401.16 Compaction
401.17 Joints
401.18 Asphalt Binder Compatibility
401.19 Spreading and Surface Tolerances
401.20 Asphalt Binder Price Adjustment
401.21 Method of Measurement
401.22 Basis of Payment

401.01 Description. This specification is applicable to all types of asphalt concrete pavements irrespective of gradation of aggregate, kind, and amount of asphalt binder, or pavement use. Deviations from these general requirements are covered in the specific requirements for each type according to the appropriate contract item or items.

Work consists of one or more courses of asphalt concrete constructed on a prepared foundation. The asphalt concrete consists of a mixture of graded aggregate and specified type and grade of asphalt binder.

Control all production processes to assure the Engineer that the mixture delivered to the paving site is uniform in composition, conforms to the specification requirements and that the placed mixture is free of any defect (ex. segregation, tenderness, lack of mixture and texture uniformity, raveling, flushing, rutting, holes, debris etc.) within the Contractor's control at project completion.

The asphalt concrete pavement thickness shown on the plans or stated in the Proposal is for the exclusive use in calculating the weight required to be placed per unit of surface area.

401.02 Mix Design and Quality Control. Use an approved Job Mix Formula (JMF). The quality control and acceptance requirements of Item 403 apply unless otherwise specified.

If required to perform the mix design or quality control, provide a laboratory and personnel meeting the requirements of City Supplement 1041 to perform mix design and quality control tests.

Calibrate asphalt content nuclear gauges according to City Supplement 1043 using personnel with a minimum Level 2 approval according to City Supplement 1041. Mix and test the calibration verification sample with a City employee present.

Provide and dispose of the solvent used for cleaning the asphalt content nuclear gauge pans.

401.03 Materials. Furnish materials conforming to:

Asphalt binder
(asphalt concrete, 401.14, 401.15)..... 702.01
Asphalt material (401.14, 401.18).....
..... ODOT SS875.02, 702.01, 702.04, or 702.13
Aggregates (base courses)..... 703.04
Aggregates (intermediate and
surface courses)..... 703.05
Mineral filler 703.07

Sample aggregate, asphalt binder, asphalt material, and mineral filler according to 106.01.

Take prompt corrective action if mixture delivered to the paving site is not uniform in composition, does not conform to the specification requirements or is not free of any defect (ex. segregation, tenderness, lack of mixture and texture uniformity, raveling, flushing, rutting, holes, debris etc.) within the Contractor's control as determined by the Engineer. The Engineer will stop conditional acceptance of the asphalt concrete for failure to correct problems.

401.04 Reclaimed Asphalt Concrete Pavement. The Contractor may blend reclaimed asphalt concrete pavement (RAP) into the mix according to the following requirements. Failure to follow these requirements will result in a rejection of the Contractor QCP (403.03); restriction of RAP use at the facility; or shutting down production at the facility.

Job Mix Formula. The Contractor may use a blend of new materials in combination with RAP obtained from verifiable City of Columbus, ODOT projects. If the RAP is not from the above sources or the source is unknown, process and blend the RAP into a single uniform stockpile, test according to Level 3 Asphalt Mix Design requirements and obtain City approval for use. Obtain Laboratory written approval for use of unusually large, old RAP stockpiles of unknown content and/or age. Include approved methods in the QCP for ongoing processing and testing of these piles. Ensure no foreign or deleterious material (703.04, 703.05) is present in RAP.

Ensure that the JMF falls within the specified limits of the required mix item. Ensure the JMF submittal includes the percentages of RAP, virgin aggregates, and virgin asphalt binder required for the mix item. Report all RAP test results, including binder blend analysis, in the JMF submittal. Identify the RAP in the JMF submittal as to project origin and mix type(s).

Determine RAP properties and uniformity as follows. Determine the final RAP gradation and asphalt binder content on a minimum of four separate stockpile (or roadway for concurrent grinding) samples all agreeing within a range of 0.4 percent for asphalt binder content and 5 percent passing the No. 4 sieve. If fractionated RAP is used, use a suitable sieve for determining gradation uniformity. Determine RAP binder content from a centrifuge extraction test. Do not use reflux extraction or oven burnoff.

RAP Usage Limits and Requirements. Process and use RAP as follows.

Process and use RAP by one of the following two methods. Note on the JMF submittal RAP page which of Method 1 or Method 2 methods described below apply to the RAP. Use PG64-28 virgin binder in all 442 intermediate courses regardless of the percentage of RAP used. If greater than 25 percent RAP is used in a JMF submittal, use PG58-28 or PG64-28 virgin binder. If 26-30 percent RAP is used in the JMF submittal, the Contractor may submit a 3000 gram RAP sample along with a blend chart, according to Level 3 Mix Design procedures, to determine the grade of virgin asphalt binder to use. The City may request RAP samples or binder properties at any time.

A. Method 1 Standard RAP. Include RAP in a JMF submittal according to the Standard RAP Limits Table 401.04-1 unless specified differently in the applicable mix specification. For mixes that will contain up to 10 percent RAP, the JMF submittal is not required to include the RAP except when a virgin polymer asphalt binder is used in a surface course. For surface course JMFs having polymer asphalt binder only submit at 0 or 10 percent RAP.

TABLE 401.04-1 METHOD 1 – STANDARD RAP LIMITS

Asphalt Mix Application	Percent RAP by Dry Weight of Mix, Max.	Total Virgin Asphalt Binder Content, Min.	Comments
442 Polymer Surface Course	10%	5.2	Polymerized binder is virgin. (For non-polymer virgin binder allow 20% max RAP.)
441 Surface Course	20%	5.0	Polymer or non-polymer virgin.
441, 442 Intermediate Course	35%	3.0	Any mix type used as an intermediate course.
301 Base Course	50%	2.7	The Laboratory will establish the asphalt binder content.
302 Base Course	40% (30%)	2.0	A lower RAP limit of 30 percent will be required if poor production mixing or coating is evident.

RAP Processing for Table 401.04-1 Method 1-Standard RAP. For surface courses process RAP to less than 0.75 inch and place a 0.75 inch screen on the cold feed. For other courses place a 2-inch screen on the cold feed. Ensure that the RAP is the proper size to allow for complete breakdown in the plant. If mixing is incomplete, place a smaller screen on the cold feed.

B. Method 2 Extended RAP. Include RAP in a JMF submittal according to the Extended RAP Limits Table 401.04-2 unless specified differently in the applicable mix specification. Only use Method 2 with counter flow drum plants or mini-drum batch plant configurations meeting Item 402. For mixes that will contain up to 15 percent RAP, the JMF submittal is not required to include the RAP unless a virgin polymer asphalt binder is used in a surface course. For JMFs having polymer asphalt binder do not submit at 1 through 9 percent RAP.

TABLE 401.04-2 METHOD 2-EXTENDED RAP LIMITS

Asphalt Mix Application	Percent RAP by Dry Weight of Mix, Max.	Total Virgin Asphalt Binder Content, Min.	Comments
442 Polymer Surface Course	15%	5.0	Polymerized binder is virgin. (For non-polymer virgin binder allow 25% max RAP.)
441 Surface Course	25%	5.0	Polymer or non-polymer virgin.
441, 442 Intermediate Course	40%	3.0	Any mix type used as an intermediate course.
301 Base Course	55%	2.5	The Laboratory will establish the asphalt binder content.
302 Base Course	45% (35%)	1.8	A lower limit of 35 percent will be required if poor coating is evident. The virgin requirement of 302.02 does not apply.

RAP Processing for Table 401.04-2 Method 2-Extended RAP. Process RAP by means of fractionation or by additional in line processing. Include in the QCP additional methods and procedures to dictate how this is to be accomplished at plants. Specify documentation method for RAP measurement. Fractionation is the process of creating separate piles of RAP from one pile when split over a specific sieve or sieves. Test fractionated piles to show uniformity. For additional in line processing only process RAP from a uniform, tested and approved stockpile by passing the RAP over a double deck screen placed in-line between the RAP cold feed bin and the mixer. Use a 9/16 inch screen for surface and intermediate mixes and a 1.5 inch screen for base mixes. Do not use concurrent project RAP in a stream process.

RAP QC and Management Requirements.

Always note on the daily quality control report how much RAP is actually being used. Apply a tolerance of ± 5.0 percent on the amount of RAP used if needed for a quality control adjustment but do not exceed the limits of Table 401.04-1 or Table 401.04-2, whichever applies. If this adjustment is not adequate for maintaining control of the mix submit a new JMF for approval.

Include in the QCP methods to be used to meet Method 1 and Method 2 requirements above and the following requirements:

1. Provide enough space for meeting all RAP handling requirements at a hot mix facility.
2. Provide a clean, graded base for stockpiles that does not collect water.
3. Test blended RAP stockpiles to assure uniform gradation and asphalt binder content.
4. Ensure uniform stockpile properties match the JMF submitted RAP properties unless the uniform stockpile will be processed into the asphalt plant using plant cold feed in line processing.

If the uniform stockpile will be processed into the asphalt plant using plant cold feed in line processing determine the processed RAP properties for use in the mix design. Record in the JMF submittal both the uniform stockpile and in line processed RAP properties.

When applying Method 1 Standard RAP requirements, the Contractor may use concurrent City or ODOT project RAP in a stream process in place of stockpiling and testing for uniformity. Take Concurrent project RAP from one existing mix type on the concurrent project or two existing mix types if both mix types are taken at the same time in one pass of the milling machine. Submit a new JMF for each existing mix type on the project (or each milling pass of two types) desired for use as concurrent project RAP. Include in the QCP methods of validating RAP properties when using concurrent project RAP. If these requirements are not met, blend and test for uniformity and apply the stockpile requirements of this specification.

Maintain in the plant lab and control room an up to date and dated site map of all tested and untested RAP stockpiles. Give each stockpile a unique identification. Provide in the plant lab RAP properties for each uniform, blended stockpile cross referenced with its identification. In addition, provide the date the stockpile processing was completed and the stockpile estimated size in tons. Provide signage at all RAP piles. Do not add to a stockpile once it is tested for uniformity. Provide signage at all uniform stockpiles to inform haulers that uniform piles are not to be added to.

Stockpiles and processing methods are subject to inspection and approval by the Engineer at any time. Rejection of stockpiles can occur for the presence of foreign or deleterious materials, lack of uniformity, incomplete mixing in the asphalt mixture, adding to piles, or moving RAP in a way not traceable through the QCP records and methods. The Laboratory will resolve disputes over acceptability of RAP.

401.05 Mixing Plants. The City will approve mixing plants before preparation of the mixtures. Schedule a date with the City for approval inspection to be at least 1 week before mix production. Do not produce mixtures for projects from un-approved plants. General requirements for

asphalt concrete mixing plants are specified in Item 402. Set the asphalt binder controls for the computerized plant at the virgin asphalt binder content of the JMF at all times unless change is authorized by the Laboratory.

Asphalt mixtures may be produced using the warm mix asphalt method according to 402.04, except as restricted by specification.

401.06 Weather Limitations. Place asphalt concrete only if the surface is dry and if weather conditions are such that proper handling, finishing, and compaction can be accomplished. Never place asphalt concrete if the surface temperature is below the minimum established in Table 401.06-1.

TABLE 401.06-1

Course Thickness	Minimum Surface Temperature
3.0 inches and over	36 °F [1]
1.5 to 2.9 inches	40 °F
1.0 to 1.4 inches	50 °F
Less than 1.0 inch	60 °F
Variable Intermediate, 0 to 3.0 inches	40 °F
[1] Instead of 36 °F, use a minimum air temperature of 40 °F if paving on an aggregate base or subgrade.	

In addition to the above surface temperature requirements, do not place surface courses if the air temperature is less than 40 °F.

For any surface course with a polymer modified asphalt binder, ensure that the paving surface is at least 50 °F and the air temperature is at least 50 °F.

Do not schedule the placement of any surface course with a polymer modified asphalt binder after November 1, regardless of pavement or air temperature.

401.07 Notification. Notify the Engineer at least 24 hours before starting paving on a project. After starting, if paving operations are stopped for 1 week or more, notify the Engineer at least 24 hours before resuming paving on a project.

401.08 Asphalt Binder. Heat the asphalt binder and deliver it to the mixer within the temperature range specified in Table 702.00-1. Do not use asphalt binder while it is foaming in a storage tank. Take samples using correct new containers from the binder line between the last piping 'tee' and inlet into the plant unless a different storage method requires a different sampling location.

401.09 Aggregate Preparation. Feed aggregates in their proper proportions and at a rate to permit correct and uniform control of heating and drying. Remove all aggregates in the plant that will produce a mix outside the temperature limits or that contain excessive moisture or expanding gases causing foaming in the mixture, and return them to the proper stockpiles.

401.10 Mixing. Maintain the temperature of the mix at the plant within the range in JMF or according to the specification. Ensure the mixture is workable and temperature is sufficient for compaction at the point of placement. The Engineer will verify the required temperature of the mixture on arrival at the project site based on the temperature range in the JMF and heat losses in transit.

For batch plants, after all of the aggregate is in the mixer, add the asphalt binder in an evenly spread sheet over the full length of the mixer. The mixing time is defined as the interval between the start of application of the asphalt binder and the opening of the mixer gate. Discharge all asphalt binder required for one batch in 30 seconds or less. After the asphalt binder is added, apply the mixing time determined by the Laboratory but not less than 30 seconds.

401.11 Hauling. Use trucks for hauling asphalt concrete that have tight, clean, smooth metal beds from which the entire quantity of mixture is discharged smoothly into the spreading equipment.

Before loading, apply a thin coating of an approved release agent to the inside surfaces of the truck bed to prevent adhesion of mixture to the bed surfaces. The Laboratory maintains a list of approved release agents. Do not use fuel oil for this purpose. Drain truck beds after applying the release agent and before loading. Load trucks in manner to minimize segregation of the mixture according to the approved QCP.

Do not clean out truck beds on the roadway ahead of the paver. Provide a location away from the roadway or off the project for cleaning trucks. If there is excessive sticking of material in truck beds, the sticking is in areas of the truck that would indicate excessive cooling of the mix (front corners, bottom, etc.) due to a long haul, and it is not resolved in a reasonable time, the Engineer will require an insulated bed. The Contractor may only make procedure changes for better mix handling at the discretion of the Laboratory.

Equip each truck with a securely fastened, waterproof cover of suitable material to protect the mixture from wind and weather. At the request of the Engineer, remove covers before dumping into the paver.

If transporting hot asphalt concrete at prevailing air temperatures below 50 °F or if the length of haul exceeds 20 miles, insulate all truck beds to maintain workable mix temperature, and ensure that all covers are fastened to exclude the wind. Do not exceed a distance of 50 miles from the asphalt concrete plant to the paving site except by specific permission of the City.

401.12 Spreading Equipment. Use self-contained spreading equipment of sufficient size, power, and stability to receive, distribute, and strike-off the asphalt concrete at rates and widths meeting the typical sections and other details shown on the plans. Use spreading equipment that has

automatic control systems that maintain the screed in a constant position relative to profile and cross-slope references. Ensure control of the screed position is reasonably independent of irregularities in the underlying surface and of the spreader operation. Equip asphalt spreading equipment to prevent the segregation of coarse aggregate from the remainder of the asphalt concrete when the material moves from the hopper to the screed. Use means and methods approved by the asphalt spreader manufacturer consisting of but not limited to any combination of chain curtains, deflector plates, or other such devices.

The Engineer will base final approval of spreading equipment on the demonstrated capability of the equipment to place the mixture to the required cross-section, profile and alignment in an acceptable, finished condition ready for compaction.

Where the use of standard full-scale spreading equipment is impractical due to the size or irregularity of the area to be paved, use specialized equipment or hand methods approved by the Engineer to spread the asphalt concrete.

401.13 Rollers. Use only steel wheel and pneumatic tire types of rollers meeting the minimum requirements of the following tables. Conform to manufacturer's specifications for all ballasting.

TABLE 401.13-1 ROLLER CAPACITY

Roller Type	Maximum Capacity square yards per hour
Tandem	700
Three-Wheel	700
Trench	15 per inch width
Pneumatic Tire, Type I	1000
Pneumatic Tire, Type II	700
Vibratory, Vibrating Roll	15 per inch width
Vibratory, Static Roll (not vibrating)	3 per inch width

TABLE 401.13-2 STEEL WHEEL ROLLERS

Roller Type	Three-Wheel	Tandem	Vibratory Static	Trench
Total weight, tons	10	8 to 12	8 to 12	
Compression rolls, pounds per inch width, minimum	300	200	120	300

TABLE 401.13-3 PNEUMATIC TIRE ROLLERS

Type I	
Tire size, minimum	9.00 × 20 in
Wheel load, minimum	5000 lb
Average tire contact pressure, minimum	85 psi
Type II	
Tire size, minimum	7.50 × 15 in
Wheel load, minimum	2000 lb
Average tire contact pressure, minimum	55 psi

For pneumatic tire rollers, use self-propelled, reversible units with vertical oscillation on all wheels on at least one axle. Determine the tire inflation pressure necessary to meet the specified minimum contact area and contact pressure requirements. Furnish the tire manufacturer's charts or tabulations to the Engineer for verification of the required inflation pressure. Check tire inflation pressure as the Engineer directs and maintain it within 5 pounds per square inch of the required pressure.

Provide rolls and wheels with the necessary accessories to prevent adhesion of the mixture, and keep them properly moistened with water, water containing a detergent, or water containing an approved additive. Do not use excess liquid.

401.14 Conditioning Existing Surface. Clean the surface on which the asphalt concrete is to be placed, and keep it free of accumulations of materials that would, in the judgment of the Engineer, contaminate the mixture, prevent bonding, or interfere with spreading operations. Where approved subgrade or pavement courses previously constructed under the Contract become loosened, rutted, or otherwise defective, correct the deficiency according to the contract item or items involved before the spreading of a subsequent pavement course.

If a quantity of asphalt concrete is specified for use in spot leveling or patching, spread and compact the material needed to effect the corrections as directed by the Engineer.

If placing asphalt concrete against a vertical pavement face, curb, gutter, manhole, or other structure, clean the surface of foreign material and apply a thick, uniform coating of 702.01 PG binder, ODOT Supplemental Specification 875.02 Hot Applied Asphaltic Joint Adhesive, or 702.13 SBR Asphalt Emulsion to provide 100 percent coverage, except do not use 702.13 for longitudinal pavement joints.

401.15 Spreading, Finishing and Night Work.

A. Spreading and Finishing. Do not co-mingle multiple JMFs in the same asphalt paver. Spread the mixture at a rate calculated using the specified thickness and the compacted width of the pavement course being placed, and the weight-to-volume conversion factors established in 401.21. Maintain the actual rate of spreading the mixture equal to the required calculated rate within the tolerance specified in 401.19. For pavement courses specified for leveling, the actual rate of spreading the mixture may vary from the required calculated rate as approved by the Engineer to accomplish the intended purpose.

For intermediate courses, make the maximum compacted depth of any one layer 3 inches.

Spread and finish the mixture using approved equipment or methods such that compaction can follow immediately. Preheat screeds and extensions before placing any asphalt concrete. Use side plates sufficient to contain the mixture laterally during spreading. Use only screed extensions, rigid or extendable, having the same features as the main screed including, but not limited to, vibration, heating, prestrikeoffs, and tamping bars. When using front-mounted hydraulically extendable screeds at a fixed paving width, use full width auger extensions and full tunnel extensions. When using fixed screed extensions, use full width auger extensions and full tunnel extensions. Do not allow a buildup of excess material in front of the screed. Where excessive buildup of material is not controlled, the Engineer will require paver changes to correct the problem.

Ensure the paver operation, screed, screed extension, and, or, mix design provide a mat, prior to compaction, that is free of texture inconsistencies, shadowing, streaking, tearing, pulling, or other deficiencies. Take immediate action to correct the paver operation, screed, screed extensions, or, mix design. The Engineer may stop placement until corrections are completed.

Use strike-off plates/strike-off extensions only on irregular areas such as mailbox turnouts, driveway turnouts, and other irregular non-travelled roadway areas. The Engineer may approve the use of strike-off plates/extensions on variable width shoulders if the use of a standard extendable screed extension with the same features as the main screed is not practicable. Perform supplemental hand forming and tamping where irregularities develop and where placing the mixture by hand methods.

Take prompt corrective action if placed mixture exhibits any defect (ex. segregation, tenderness, lack of mixture and texture uniformity, raveling, flushing, rutting, holes, debris etc.) within the Contractor's control and as determined by the Engineer. Remove and replace, or otherwise correct in a manner satisfactory to the Engineer, any portion of the pavement course found to be defective in surface texture or composition before or after compaction. Coordinate the spreading operation with the rate of production and delivery of the mixture to attain uniform, continuous progress. Avoid erratic spreader operation due to irregular contact with the hauling vehicle, surging in the feed and distribution of the mixture, or other cause. Maintain sufficient control of the spreading equipment with regard to line and grade references so that the pavement course, when compacted as specified, is in reasonable conformance with the Contract Documents.

Do not displace or damage bridge deck waterproofing membranes during spreading operations on the membranes.

Do not allow traffic on the compacted mixture until it has cooled sufficiently to prevent glazing as determined by the Engineer.

After completion of the surface course, seal gutters with asphalt binder as directed by the Engineer. Apply the material at a uniform width of approximately 4 inches and at a rate just sufficient to fill surface voids.

B. Night Work. Do not start night work or carry on day work into night work without operating an adequate and approved lighting system. Night work is defined as work performed from 30 minutes after sunset to 30 minutes before sunrise.

Operation of adequate lighting system consists of furnishing, installing, operating, maintaining, moving, and removing night time lighting to illuminate construction work areas for night work. Obtain the Engineer's approval of the lighting at the beginning of the project and before starting the paving operation by measuring the luminance.

Provide an illuminated zone around all operating machinery. Provide an illuminated zone of at least 5 Foot-candles of lighting luminance in the immediate vicinity of pavers, rollers, grinding equipment, material transfer vehicles, etc., and at least 1 Foot-candle at 25 feet from this equipment. Provide an illuminated zone of at least 5 Foot-candles of lighting luminance in the immediate vicinity of coring equipment and at least 1 Foot-candle at 10 feet. Position the light sources so they do not interfere with or impede traffic in any direction and do not cause glare for motorists or point onto adjacent properties. Provide a photometer capable of measuring the level of luminance on each night project. Take luminance measurements at a height of 20 inches above the roadway.

Obtain the luminance level any time requested by the Engineer. Test the illumination levels on the site each time a change in lighting configuration is made. Replace non-functioning lamps immediately. Check the luminaires aiming daily. Clean the luminaires regularly. Correct any deficient lighting within one hour or the Engineer will terminate construction activities.

401.16 Compaction. Immediately after spreading the asphalt concrete and adjusting any surface irregularities, compact the mixture uniformly using rollers conforming to 401.13. Do not use a spreading rate that exceeds the total of the specified capacities of the rollers in use. However, if compacting a mixture spread as an intermediate or pre-leveling course less than 1-inch thick, do not use a spreading rate that exceeds twice the total capacity of the rollers in use.

Coordinate the spreading of the mixture with the required roller coverage, considering the rate of cooling of the mixture as affected by lift thickness and environmental conditions. Complete the required roller coverage during the period of time in which the temperature of the mixture is sufficient for the roller coverage to be effective in compacting the mixture.

Compact base mixtures using a combination of both steel wheel and Type I pneumatic tire rollers; however, in small areas, compact these mixtures as the Engineer approves using any of the rollers specified in 401.13.

Compact intermediate and surface mixtures using a three-wheel roller in the breakdown position (roller immediately behind the paver) of the roller train; however, in small areas, compact these mixtures as the Engineer approves using any of the roller types specified in 401.13.

Compact variable depth courses using a combination of both steel wheel and pneumatic tire rollers; however, in small areas, compact these mixtures as the Engineer approves using any of the roller types specified in 401.13.

For surface courses using a polymer modified asphalt binder, give a copy of the JMF approval letter containing the design compaction temperature to the Laboratory before any mix is placed. Unless otherwise specified, ensure that the mix temperature immediately before rolling is not less than 290 °F if placing hot mix asphalt, and not less than 250 °F if placing warm mix asphalt according to 402.04. Do not compact polymer asphalt concrete surface courses with pneumatic tire rollers.

When using pneumatic tire rollers, ensure for any mix that surface deviations and deformations caused by the tires are removed with steel wheel rollers. Do not use pneumatic tire rollers if any resultant surface deformations cannot be removed.

Do not use vibratory rollers on courses with a thickness under 1 1/2 inches.

If using vibratory rollers, supplement them with three-wheel or pneumatic tire rollers.

Unless otherwise directed, begin rolling at the sides and proceed longitudinally parallel to the centerline at a slow, uniform speed. After each coverage or complete round trip, move the roller towards the crown of the road to begin its next pass, overlapping the previous pass by at least one-half the width of the previous pass. On superelevated curves, begin rolling at the low side and progress toward the high side. Where a longitudinal joint is being made, roll the joint then follow the applicable rolling procedure.

Continue rolling until full coverage of the course is complete and all roller marks are eliminated. Take care to prevent displacement of the edgeline and grade. Where displacement occurs, correct the area immediately in a manner satisfactory to the Engineer.

Along curbs, headers, walls, and in other areas not accessible to rollers, thoroughly compact the mixture with hot, hand tampers or with mechanical tampers. On depressed areas, the Contractor may use trench rollers or rollers fitted with compression strips.

Replace mixture that becomes loose, broken, contaminated, or otherwise defective with fresh, hot mixture. Compact it to match with the surrounding area.

401.17 Joints. Place the asphalt concrete mixture as continuous as possible. Set up joints at the proper height above the adjacent construction to receive maximum compaction. Where the edge of the new pavement is significantly rounded by the action of traffic, trim it to a vertical face before placing the adjacent pavement. On projects where traffic is allowed to cross the edge of the new pavement lane, complete the longitudinal joint of the adjacent lane or shoulder within 24 hours.

Construct longitudinal joints using string line or other controls as a point of reference to provide a straight longitudinal joint. Prior to placing adjacent pavement, trim any locations along the longitudinal joint that deviate horizontally from the point of reference. Maintain a consistent overlap of 1 to 1 1/2 inches on adjacent pavement when closing longitudinal joints. Where phasing for maintenance of traffic will not allow lapping cold longitudinal joints according to ODOT's Standard Drawing BP-3.1, provide a minimum of 6 inches offset between cold joints for each course placed.

Form hot longitudinal joints using pavers operating in contiguous lanes, one just ahead of the other. Maintain the distance between pavers in adjacent lanes such that it does not exceed the distance that a normal size load of mixture will cover. Alternate loads of mixture between the pavers. Do not allow rollers performing the initial rolling operation in one lane closer than 12 inches to the longitudinal joint until the adjacent lane is placed.

Instead of hot joint construction using multiple pavers, the Contractor may use full width construction with a single unit paver.

For surface courses, form or cut all transverse construction joints to a vertical.

Seal all longitudinal construction joints by coating the entire face of the joint with a certified 702.01 PG binder or ODOT Supplemental Specification 875.02 Hot Applied Asphaltic Joint Adhesive to provide 100 percent coverage of the joint. Overlap the joint edges by at least 1/2 inch. Seal all transverse construction joints with a certified 702.01 PG binder, ODOT Supplemental Specification 875.02 Hot Applied Asphaltic Joint Adhesive or 702.13 SBR Asphalt Emulsion to provide 100 percent coverage of the joint or with a certified 702.04 asphalt material applied at a rate of 0.25 gallon per square yard.

401.18 Asphalt Binder Compatibility. If excess fat spots, regular random areas of flushing, or excess drain down occur on a project that are not attributable to over rolling, plant operation, or mix quality compared to the JMF, the City will consider the asphalt binder incompatible. The City will reject any on-hand asphalt binder because of incompatibility. The City may use its discretion in determining if problem areas can be corrected, or if removal and replacement is required. Demonstrate to the Laboratory through reporting actual testing analysis the compatibility of another asphalt binder and that proper equipment is in place in order to be allowed to resume.

401.19 Spreading and Surface Tolerances. If a uniform course is specified, make checks and adjustments to maintain the rate of spreading within a tolerance of ±5 percent of the required calculated weight per unit of area.

If a variable depth course is specified, place the mixture as shown on the plans.

If a longitudinal profile is specified by elevations on the plans, do not allow the completed pavement surface to deviate more than 1/2 inch at any point from parallel with the specified profile. Before placing the surface course, check the profile of the preceding course at 50-foot intervals along the outside edge of each traffic lane and along any additional line described in superelevation tables, and submit a tabulation of all results that includes documentation of all deviations from the above tolerance to the Engineer. Perform corrective work necessary for compliance with the

profile tolerance before placing the surface course. The requirements of this paragraph do not apply to small incidental areas of pavement less than 500 feet in length.

Do not vary the transverse slope of the surface of the completed course from the specified slope by more than 3/8 inch in 10 feet.

Do not vary the surface of each completed intermediate or surface course from the testing edge of a 10-foot rolling straightedge by more than 1/4 inch. Furnish straightedges, straightedges equipped with levels, or other devices. Equipment will be satisfactory to the Engineer.

Check the surface course for variations in slope or surface at locations where bumps are suspected when directed by the Engineer.

Correct variations in excess of slope or surface tolerance by removing mixture to neat lines and replacing, or by surface grinding in a manner satisfactory to the Engineer.

401.20 Asphalt Binder Price Adjustment. A Contract Item is eligible for a price adjustment when the Contract's proposal specifically includes an Asphalt Binder Price Adjustment note.

401.21 Method of Measurement. The Contractor is responsible for recording the net weight of each truckload of mixture to the nearest 100 pounds in triplicate on plant ticket forms approved by the City. If the pay quantities are established by platform scales, provide a tare weight for each truck at the beginning of each day's operation and a minimum of every 4 hours of operation each day. The Engineer may require additional tare weight measurements at any time. The Engineer will have the right to monitor all weighing operations and may require reweighing trucks at any time or location. Correct any discrepancies immediately. Continued non-compliance will result in the City taking necessary and appropriate action, such as, but not limited to, assigning a City ticket writer to the plant. Send one copy of the plant ticket with each load delivered to the paver and present it to the Engineer.

The Engineer will convert the total of the weights recorded on the plant tickets representing mixture finished according to contract requirements to cubic yards using a conversion factor established by the Laboratory. The Laboratory will establish this conversion factor from the approved JMF. However, if a mix design is not available, the Laboratory will use the conversion factors in Table 401.21. If a uniform course is specified, the City will not pay for a number of cubic yards that exceeds the quantity calculated from plan lines and dimensions.

TABLE 401.21

Aggregate	**lb/yd^3**
Gravel and stone	4000
Slag less than 90 lb/yd^3[1]	3600
Slag 90 to 100 lb/yd^3[1]	4000
Slag more than 100 lb/yd^3[1]	4300
[1]Based on average dry rodded weight at the Laboratory.	

401.22 Basis of Payment. The City will pay for all work performed and measured as specified above according to the appropriate contract items for each type.

The cost of sealing the joints is included in the unit price bid for the asphalt concrete.

The City will assess all costs against the Contractor that it incurs as a result of taking necessary and appropriate action due to the Contractor's continued non-compliance.

The City will not pay for removing and replacing incompatible asphalt binder areas.

ITEM 402 ASPHALT CONCRETE MIXING PLANTS

402.01 Description
402.02 Calibration
402.03 Polymer Binders
402.04 Water Injection System for Warm Mix Asphalt

402.01 Description. This specification consists of the minimum requirements for an asphalt concrete mixing plant to produce asphalt concrete mixes according to City specifications.

Ensure asphalt concrete mixing plants conform to the requirements of City Supplement 1101 and ASTM D 995 in addition to the following.

402.02 Calibration. Ensure the plant is calibrated according to City Supplement 1101 when producing any asphalt concrete for the City. Ensure that the calibration is accurate within 1.0 percent. When performing a complete calibration for City projects, notify the Laboratory 24 hours in advance of the calibration. Submit a letter to the Laboratory verifying the plant has been calibrated in accordance with City Supplement 1101.

402.03 Polymer Binders. If an asphalt binder is modified by SBR at an asphalt concrete mixing plant, equip the plant with an automated SBR flow control and monitoring system. Obtain the Laboratory's approval of the system before operating and demonstrate the system calibration to the City. If the City waives the demonstration, provide a letter documenting calibration data for the flow system to the Engineer for each project. Obtain written approval from the Laboratory for the use of SBR and ensure the QCP contains methods for properly controlling and sampling SBR binder blends.

For drum mix plants, introduce the SBR directly into the asphalt binder line through means of an in-line motionless blender or other device approved by the Laboratory which is able to provide a homogeneous blend. Ensure the in-line motionless blender design provides aggressive interaction of asphalt binder and SBR emulsion to provide a homogenous blend at the sampling port. Some blenders such as 'swirl' type blenders do not accomplish proper blending. The Astec in line SBR blender or similar design accomplishes proper blending. Locate a sampling valve between the in-line blender and the plant drum, at least 12 ft downstream of the in-line blender and at least 5 ft downstream of a piping elbow. Ensure the sampling valve port is at least 1 in in diameter. Ensure the sampling valve can be opened quickly for maximizing sample flow for the purpose of obtaining a proper sample. In place of an in-line sampling valve, a sample may be taken from a 3 to 5 gal surge tank as long as the tank is downstream of the required blender and the in-line flow can be quickly and directly diverted to the surge tank. Contents of the tank should be drained into a 5 gal sampling bucket and stirred before filling the required sample container. Provide a sampling valve port that is in a position to safely obtain the required sample volume in the required 5 gal sampling bucket. Provide a stable sampling rack to obtain a sample.

For batch plants, add the SBR after the aggregate has been completely coated with asphalt binder. Continue mixing for a minimum of 20 seconds after SBR is added and long enough to provide a uniform mixture.

Ensure the SBR pumping and metering system is capable of adding the SBR within the limits of 702.01. For drum plants ensure the SBR pump is automatically controlled by an independent computer and interfaced with the asphalt binder flow to automatically maintain the SBR flow within specification limits. Produce asphalt mixtures for placement in automatic SBR control mode only.

Ensure the SBR meter is accurate to +/- 2.0 percent over a flow range typical of that used at the asphalt plant (typically 0.8 to 12 gpm at drum plants and 10 to 25 gpm at batch plants). Ensure the SBR meter is a magnetic flow meter consisting of a metering flow tube which utilizes Faraday's Law of Induction to measure the flow and includes a transmitter to transmit the flow signal to a totalizer located in the control room of the asphalt plant. Locate the SBR meter downstream of any recirculation lines. Provide a means for removing the SBR line at the in-line blender to be able to obtain a sample of the SBR for calibration purposes.

Obtain Laboratory approval for use of any other type of SBR meter. Ensure the totalizer displays total volume measured and flow rate in standard engineering units. Ensure the totalizer is interfaced with a data logger that produces printouts of the logged data every five minutes for a drum plant or every batch for a batch plant. Ensure the logged data includes time, date, flow rate, and flow total except flow rate is not necessary for batch plant production.

Balling or wadding of SBR or uncoated aggregate indicates improper mixing; cease production immediately and until corrected to Laboratory satisfaction.

402.04 Water Injection System for Warm Mix Asphalt.

When allowed by specification, use a City approved water injection system for the purpose of foaming the asphalt binder and lowering the mixture temperature. Only use equipment that has been proven stable and effective through project use on non-City projects. Ensure equipment for water injection meets the following requirements:

A. Injection equipment computer controls are in the plant control room and are tied to the plant computer metering.

B. Injection equipment has variable water injection control controlled by the plant operation rate and the water injection can never exceed 2.2 percent by weight of asphalt binder.

C. Water injection rate cannot be manually overridden by the plant operator once in the computer.

D. Injection equipment stops water flow when a control or equipment failure in the injection system occurs.

E. The water injects into the asphalt binder flow before the asphalt binder spray hits aggregate. Do not allow water to touch aggregate before the binder spray.

F. Injection equipment includes water storage and pump control tied to the injection computer controls.

G. Water storage low water alarm installed in the control room.

H. Provide a PG binder sampling valve between the last piping tee on the tank side of the line and the injection equipment to sample PG binder before water is injected.

ITEM 403 ASPHALT CONCRETE QUALITY CONTROL AND ACCEPTANCE

403.01 Description
403.02 General
403.03 Quality Control Program (QCP)
403.04 Plant Calibration
403.05 Quality Control Tests
403.06 Verification Acceptance (VA)
403.07 Not Used
403.08 Acceptance Tables for 448 Mixes

403.01 Description. This specification outlines the Contractor requirements for controlling asphalt concrete, asphalt concrete base, or other asphalt mixtures as specified.

403.02 General. The City will verify quality control by City Verification Acceptance (VA) tests and monitoring reviews as specified. If the Contractor fails to operate according to its Quality Control Program (QCP), the City will shut down production.

Acceptance does not relieve the Contractor of responsibility for supplying and installing a finished product conforming to all requirements of the Contract.

Follow City Supplement 1041 for the administration of a Quality Assurance Program on the Project.

403.03 Quality Control Program (QCP). Create and implement a Quality Control Program (QCP) for each paving season. The QCP will cover processes conducted to provide an asphalt mixture at the paving site that is uniform in composition, conforms to the specification requirements and that when placed is free of any defect (e.g. segregation, lack of mixture and texture uniformity, raveling, rutting, holes, debris etc.) within the Contractor's control at project completion. A minimum of 1 week before mix production, submit a hard copy of the proposed QCP to the Laboratory for review and acceptance.

Send a hard copy and a digital copy (if available) of the acceptance letter and accepted QCP to the Engineer. Keep copies of the letter and the QCP in each Contractor plant laboratory and plant operation control room. Digital copies of the QCP and letter in pdf format are allowed in each Contractor plant laboratory and plant operation control room with the following requirements: The file icon must be appropriately labeled and be on the computer desktop of a computer in each area, the QCP must contain page numbering and a Table of Contents inside the front cover locating all sections by page number, and out of date QCPs must be removed from the computer desktop.

Failure to comply with the approved QCP may result in removal of personnel in accordance with City Supplement 1041, removal from VA, and adversely affect the Contractor's Prequalification rating.

The QCP is a reflection of a Contractor's sincerity and ability in producing a quality product. Development of this program beyond the minimum requirements specified below is encouraged and is taken into consideration by the the City Engineer when reviewing Contractor plant operation for qualification for VA.

Include in the program:

A. The assignment of quality control responsibilities. Quality control includes all efforts required to achieve a product meeting specifications. List individuals as required below and note their designated responsibilities to meet QCP requirements. Provide a Quality Control Manager holding a City Supplement 1041 Level 3 approval and who is a company employee. Assign Level 2 technicians for all Level 2 QC testing duties, and provide a list designating their responsibilities and expected actions. Ensure only approved personnel handle and test samples at all times. If Level 2 consultant technicians are used provide a document in the QCP and to them listing designated responsibilities and expected actions (if different from employee expectations). Define who is responsible at plants and specific methods for ensuring haul vehicles meet all requirements and proper bed release products are used. Provide a Field Quality Control Supervisor (FQCS), holding City Supplement 1041 Field Quality Control Supervisor approval and who is a company employee, who is routinely and usually at the paving site during placement of any non-temporary asphalt concrete pavement. Ensure personnel obtaining and handling cores at the project site are approved Level 2 technicians, FQCS or personnel approved by the Laboratory.

B. Means for annual training of company and consultant technicians and their supervisors in ethical conduct according to company expectations. Document how and when training is given, what the expectations are, how expectations are communicated and list all personnel trained. Describe the QC Manager's and technician supervisor's responsibilities and methods in ensuring ethical conduct is maintained throughout the year.

C. Provisions to meet the City mix specifications.

D. Procedures for extra testing (e.g., job start, responses to poor test results or field mix problems, aggregate stock testing, reclaimed asphalt concrete pavement checks, moistures) and any other testing necessary to control materials not already defined in these Specifications.

E. Specify warning bands to be used by technicians for all tests and give specific instruction how the warning bands will be used for tests in concert with Table 441.10-1 specification requirements.

F. Methods to maintain all worksheets, including all handwritten records, and other test and sample records from the plant or project for the duration of the contract or 5 years, whichever is longer. Define the test record process. Define company records retention requirements. Provide copies of all test reports and forms used in the quality control process.

G. Procedures for equipment calibration and documentation for Level 2 lab equipment. Provide documentation that all Level 2 lab equipment has been calibrated at the time of the Level 2 lab approval inspection. Procedures for calibration record storage.

H. Method of Quick Calibration and documentation for each plant type.

I. Procedure for random sampling to be used at the plant and documentation method. Procedures for sample taking, tracking, handling and documentation method for all samples taken at the project paving site including taking of all cores used for density determination or density gauge correlation.

J. All procedures to meet the processing, testing and documentation requirements for RAP in 401.04 including test forms, record keeping, technician responsibilities, etc.

K. Procedure for ensuring that every Contractor employee involved in the testing of asphalt mix and operation of the asphalt plant facility has read the QCP and has on site access to all applicable City specifications, proposals, policies, and the current approved JMF.

L. Procedure for ensuring asphalt binder Bills of Lading with BOL load number, binder source and grade are reviewed against running JMFs and record of review listing the above information be kept in the plant lab for the duration of the project. Means to meet the handling and storage requirements of 402.03 and asphalt binder suppliers for all asphalt binders.

M. Means to meet delivered mixture uniformity/coating and hauling/trucking requirements.

N. Define the roles and responsibilities of the Field Quality Control Supervisors. List approved Field Quality Control Supervisors.

O. Signature of the Quality Assurance Manager and, if different, the person in authority to enforce all operations covered by the QCP as outlined in this subsection.

403.04 Plant Calibration. Conform to the requirements of Item 402.

Before manufacturing asphalt concrete, demonstrate to the Laboratory that the Contractor's facility adequately meets the specification requirements. Calibrate the plant using procedures approved by the City. Perform initial calibrations in the presence of the Laboratory. The Laboratory may request a letter of certification and certified data documenting the calibration results, instead of having the Laboratory present.

Verify the calibrations biweekly using a Quick Calibration. However, the City may request additional Quick Calibrations if there are mix production problems or plant operation concerns. The Quick Calibration is a quality control procedure developed by the Contractor that verifies the accuracy of a facility to proportion materials to meet the current JMF. Include the Quick Calibration procedure and data forms in the QCP in accordance with 403.03.H. If the difference between current calibration and the Quick Calibration is within ±2 percent, then the current calibration is acceptable. If the 2 percent variation is exceeded, perform a recalibration of the facility. Document the Quick Calibration procedure as specified in the QCP and post the procedure and results in plain view in the plant control room and plant laboratory for reference by the Laboratory. Document all data from calibrations in a format approved by the Laboratory, and retain the data for review by the Laboratory.

If asphalt concrete is being produced from a batch type facility, verify the accuracy of the aggregate and asphalt binder weighing devices on a biweekly basis. Include the verification procedure in the QCP. Document the verification procedure as specified in the QCP and post the procedure and results in plain view in the plant control room and plant laboratory for reference by the Laboratory. Do not allow the deviation between the plant recorded weights and actual weights to exceed 1 percent. Record all data from verification of weighing devices in a format approved by the Laboratory, and retain the data for review by the Laboratory.

403.05 Quality Control Tests. Perform quality control tests to control the asphalt concrete mix within the appropriate specifications.

Perform all Item 448 mix testing and quality control according to 441.09.

For mixes that do not use Item 448 acceptance (e.g. Items 301, and 302), test the mix according to 441.09 for asphalt binder content and gradation (Basic). Other requirements of 441.09 and 441.10 do not apply. Control the Basic mixes as follows:

A. If a single asphalt binder content is more than ±0.5 percent beyond the JMF, immediately take and test an additional sample.

B. If two consecutive asphalt binder content tests are more than ± 0.5 percent beyond the JMF, notify the Laboratory and cease production until the problem is corrected.

C. If the Range difference in any three consecutive asphalt binder content tests is greater than 0.7 percent (for 302 mix) or 0.6 percent (Basic mix, other than 302) immediately notify the Laboratory.

D. If the Range difference in any three consecutive gradation tests for the No. 4 sieve is greater than 10.0 percent, immediately notify the Laboratory.

E. If Range deviations as specified in 403.05.C or 403.05.D continue, cease production.

Range is defined as the difference between the largest and the smallest test result.

403.06 Verification Acceptance (VA). The City will perform VA testing. If the random City VA sampling and testing verifies the accompanying Contractor tests, the average of the Contractor's quality control tests for each day or night) will be used to determine acceptance.

A. Sampling. The City will perform the VA by testing independent and split samples taken and tested by the City.

For 441 quality control testing, the Contractor's technician will randomly select the truck in which to take a sample by using a random number procedure as outlined in the QCP. The Contractor's technician will give no indication to anyone of the time that the sample is to be taken. For other than job start, previous mix production problems, low production tonnage, or as requested by the Laboratory, exclude the first three trucks from sampling. Include the random number, sample tonnage location, and time of sampling on the daily Quality Control Report (Contractor form TE-199) with each test. Tests, other than the required random sample tests, are at the Contractor's discretion according to the QCP.

Provide a clean area of sufficient size and a hard surface to perform sample splitting. Split samples by quartering and recombining only as described in AASHTO T 248, Method B for hard surfaces for the City and Contractor's sample. The City split sample size required is generally 22 to 27 pounds. A mechanical quartering device approved by the City may be used in lieu of the above but only split according to the procedure outlined in the Contractor QCP. Ensure that every quality control or daily production sample taken by the technician has a labeled split for the City. Wrap and label the City split samples as time, location (tonnage), and accompanying Contractor test identification. The Laboratory will pick up all City split samples within 4 workdays. Sample mishandling (careless identification, changing sample size, consistency, or pre-testing) will result in shutdown of production.

For all mixes, conform to the procedures of City Supplements 1038, 1039, and 1043 except take samples from a truck at the plant. If workmanship problems continue on the project (segregation, etc.) or if quality control problems persist, the Laboratory may require sampling on the road. Split and test all samples taken by the Contractor from locations selected by the Engineer. The Contractor may test a QC sample at the required sample location as both a QC and day's production test provided the sample is tested for all required quality control properties. Test results will apply for both QC and day's production requirements. A change in the location of the sample must be approved by the City and be reasonably close to the original location. This allowance does not apply to any other samples including City VA sample locations selected by the Laboratory.

Label City split samples as day's production or quality control samples. Where more than one plant is simultaneously producing material for the job, the day's production sizes shall apply separately for each plant.

B. Reporting. Report all testing performed and sample identification on a Quality Control Report (Contractor form TE-199). Record on the TE-199 if the mixture produced was ran at the asphalt plant as a hot mix asphalt (HMA) or as a warm mix asphalt (WMA) produced according to 402.04 or another approved method. Deliver (fax, e-mail, hand) completed Quality Control Reports by the end of each day in which testing is conducted. If desired by the Laboratory and always for unsigned E-mail versions, mail the originals. After startup adjustments, report any plant operation changes on the Quality Control Report. Ensure that each Quality Control Report contains technician comments as to production quality, input materials received, and condition and includes any other quality control activities as specified in the QCP. Ongoing problems with inadequate, incomplete, or illegible reporting will result in shutdown of production. The Contractor's technician must sign each Quality Control Report.

Report test results to the accuracy of the following decimal places. When the figures to be dropped in rounding off are exactly one-half of unity in the decimal place to be retained, round the value up to the nearest number in the decimal place to be retained.

	Single Test	**Ave Range**
Asphalt Binder Content	0.1	0.01
No. 200 sieve	0.1	0.01
Other sieves	Whole number	0.1
BSG	0.001	0.001

Attach computerized plant printouts representing samples tested to that day's report, if desired by the Laboratory, or otherwise keep them with the quality control records. Ensure that the technician notes on the accompanying printout from which tonnage the quality control sample was taken with accompanying test results for AC content and percent passing the No. 4 sieve. Keep remaining printouts in the plant laboratory for the duration of the project. Keep a copy of all quality control reports for a project in the Contractor's plant laboratory.

C. City Verification Testing and Monitoring. The Laboratory will randomly choose one City sample in a maximum of every four production days for VA testing to confirm Contractor testing and mix control. More frequent VA samples can be taken when desired. The City VA sample location will be chosen randomly by the Laboratory, including where in the truck to take the sample, if applicable. The Contractor technician will take the sample from the truck with the Laboratory witnessing. The Laboratory will keep the sample in the City's possession until delivered to the Laboratory or testing is complete. The Laboratory will have enough samples taken to split with the Contractor. The Laboratory will split the sample in the Contractor lab. The Laboratory will have the sample tested in the Laboratory or as noted below. The Contractor will test his split of the VA sample with the Laboratory witnessing. The City will use its VA test result, the Contractor result of the split, as well as the most recent previous day (or night) Contractor quality control and/or day's production test in the comparison for the City VA testing.

The Laboratory may opt to test the City VA sample in the plant laboratory with the Contractor's permission, according to the Contractor's safety practices, and with the restriction of only the Contractor's technician physically placing a sample pan in the AC Gauge. However, if the Laboratory tests VA samples on Contractor equipment, test a VA sample on City equipment a minimum of one time in 15 production days from a given plant regardless of the number of projects or JMFs tested in the Level 2 lab. Record the results and testing location in the project record. One day may be added to the above City sample testing frequency for each day production is less than 500 tons.

For all mixes, the City may increase the number of VA testing samples if desired.

All City VA test results will be given to the Contractor by a reasonable arrangement acceptable to both. City VA sample testing not completed in a timely manner is of no value in verifying quality control testing quality for Contractor test acceptance and/or investigating problem causes. As such, if not completed in a timely manner, Contractor tests will automatically stand and the Engineer will note the problem in the City's VA record.

TABLE 403.06-1 VERIFICATION ACCEPTANCE AND QUALITY CONTROL TEST COMPARISON

	Percent Asphalt Binder		**Percent Passing No. 4**		**MSG Comparison**
	VA [1]	**QC/day's production test [2]**	**VA [1]**	**QC/day's production test [2]**	**VA [3]**
Basic	±0.3	±0.4	±4.0	±5.0	
448	±0.3	±0.3	±4.0	±4.0	
446					0.010

If the City VA tests confirm Contractor testing is within the verification tolerances, but a pattern of high or low results exist that suggests mix control is not at the JMF, then investigate with the Laboratory's assistance to correct the problem to the Laboratory's satisfaction. Direct any questions regarding interpretation of circumstances to the Laboratory.

D. Contractor Tests are Verified. Production is acceptable if:

1. The Laboratory verifies the Contractor's QCP is being fully followed; and
2. The City VA tests are within the limits specified in 403.06.C; and
3. For Basic mixes, the remaining sieves do not exceed the limits of the applicable specification.

Failure on the Contractor's part to respond to and resolve Laboratory concerns will result in shutting down production.

Acceptance is based on Table 403.06-2.

TABLE 403.06-2 MIX ACCEPTANCE

Mix Type	Acceptance Tolerances or Method		
		Deviation from JMF [1]	**Range**
Basic Mixes (no acceptance limits stated in appropriate specification)	Asphalt Binder Content	± 0.5%	1.0
	No. 4 sieve	± 6%	12
Basic Mixes (acceptance limits stated in appropriate specification)	Use acceptance limits in appropriate specification		
448 Acceptance Mixes	Calculate pay factor according to 403.08		
446 Acceptance Mixes	Calculate pay factor according to 446.04		
[1] Based on the average of the day or night QC Tests			

E. Contractor Tests not Verified. If the City VA test does not verify the accompanying Contractor tests within the verification tolerances, then the Laboratory will investigate.

If the deviation between the City and Contractor test is greater than the limits in Table 403.06-3, immediately cease production until resolved. If the deviation is less than the limits in Table 403.06-3 and discrepancies continue, perform additional tests to aid in problem solving.

TABLE 403.06-3 DEVIATION LIMITS

Property	Mix	Limits
Asphalt Binder Content	All	± 0.5 %
No. 4 sieve	All, except 302	± 6.0%
	302	± 7.0%

Additional tests may include any testing necessary to resolve the problem. If the additional testing does not resolve the problem by one-half production day or 500 tons, whichever occurs first, to the Laboratory's satisfaction, the Engineer may stop production until problems are resolved. Contact the Laboratory for assistance in resolving problems. If the City testing program is confirmed by the additional tests and Laboratory investigation and no reason to question the original test exists, then the original City VA tests will stand.

After the above investigation, one of the three following actions will occur:

1. Mix Production Compares Well to the JMF. If the City test and investigation shows mix is actually controlled well compared to the JMF in spite of the Contractor test, the City does not have to test additional samples if the Contractor testing problem is corrected.

2. Mix Production Does Not Compare Well to the JMF. If the City tests and investigation shows lack of Contractor mix control compared to the JMF, the City will test the remaining City split samples for the days represented by the original tests. The City will use the test results to calculate the acceptance. While working with the City, immediately take steps to correct the problem according to the QCP. Failure to achieve a quick resolution will result in shutting down production.

3. Testing Problem. If the City testing program has a problem as confirmed by the additional testing and City review, the City will correct the problem, throw out the original City test results and take new samples from the samples representing the days in question for the VA tests.

F. Contractor Removal, Restoration. If repeated problems with poor comparison of tests are not the City's fault; or poor comparison of Contractor tests to the JMF; or with plant operation, input materials, or any of the other requirements of City specifications occur in a single project or successive projects, the Laboratory will request an opinion of the City Engineer before notifying the Contractor of removal from City VA. The Laboratory will immediately notify the Contractor of the removal with a follow up letter from the Engineer. Restoration of the VA procedures may occur on a future project with a Laboratory recommendation to the City Engineer based on consistent improved plant operation and mix control, a review of the Contractor problems and resolutions, and a review of the QCP.

403.07 Not Used.

403.08 Acceptance Tables for 448 Mixes. A day's production is considered acceptable for gradation and asphalt binder content if the deviation of the mean from the JMF and the Range is no more than the tolerances shown in Table 403.08-1.

TABLE 403.08-1 DEVIATION FROM THE JMF AND RANGE TOLERANCES [1]

Mix Property	Deviation from JMF (Percent)	Range (Percent)
Asphalt Binder Content	0.3	1.0
1/2 inch sieve	6	15
No. 4 sieve	5	15
No. 8 sieve	4	15
[1] Based on the average of all daily acceptance tests.		

If the average of all daily acceptance tests for a particular sieve or sieves, or for asphalt binder content deviates from the JMF by more than the tolerances shown in Table 403.08-1, but falls within the tolerances shown in Table 403.08-2, then the day's production is considered reasonably acceptable and may remain in place with payment at a reduced pay factor as show in Table 403.08-2.

If the Range of the daily production acceptance tests for asphalt binder content or for any particular sieve, or sieves, exceeds the tolerance shown in Table 403.08-1, the City will apply a pay factor of 0.95.

TABLE 403.08-2 448 ACCEPTANCE SCHEDULE [1]

Mix Property	Pay Factor	1 Test	2 Tests	3 Tests
Asphalt Binder Content	1.00	0 to 0.47	0 to 0.36	0 to 0.30
	0.98	0.48 to 0.54	0.37 to 0.42	0.31 to 0.35
	0.90	0.55 to 0.61	0.43 to 0.48	0.36 to 0.40
	0.80	0.62 to 0.68	0.49 to 0.54	0.41 to 0.45
	0.60	0.69 to 0.75	0.55 to 0.59	0.46 to 0.50
	[2]	> 0.75	> 0.59	> 0.50
1/2 inch sieve	1.00	0 to 8.5	0 to 6.9	0 to 6.0
	0.99	8.6 to 9.9	7.0 to 8.1	6.1 to 7.0
	0.97	10.0 to 11.3	8.2 to 9.2	7.1 to 8.0
	0.94	11.4 to 12.7	9.3 to 10.4	8.1 to 9.0
	0.90	12.8 to 14.1	10.5 to 11.5	9.1 to 10.0
	[3]	> 14.1	> 11.5	> 10.0
No. 4 sieve	1.00	0 to 7.1	0 to 5.8	0 to 5.0
	0.99	7.2 to 8.5	5.9 to 6.9	5.1 to 6.0
	0.97	8.6 to 9.9	7.0 to 8.1	6.1 to 7.0
	0.94	10.0 to 11.3	8.2 to 9.2	7.1 to 8.0
	0.90	11.4 to 12.7	9.3 to 10.4	8.1 to 9.0
	[3]	> 12.7	> 10.4	> 9.0
No. 8 (2.36 mm) sieve	1.00	0 to 5.7	0 to 4.6	0 to 4.0
	0.99	5.8 to 7.1	4.7 to 5.8	4.1 to 5.0
	0.97	7.2 to 8.5	5.9 to 6.9	5.1 to 6.0
	0.94	8.6 to 9.9	7.0 to 8.1	6.1 to 7.0
	0.90	10.0 to 11.3	8.2 to 9.2	7.1 to 8.0
	[3]	> 11.3	> 9.2	>8.0

[1] Based on average of all daily acceptance tests from the JMF.
[2] Remove and replace material
[3] Engineer will determine if the material may remain in place. Pay factor for material allowed to remain in place is 0.70.

The City will determine payment for the day's production by multiplying the contract unit price by the pay factor. When any pay factors for a specific day's production are less than 1.00, use the lowest pay factor to calculate the payment.

ITEM 405 BITUMINOUS COLD MIX

405.01 Description
405.02 Composition
405.03 Materials
405.04 Mixing Plants
405.05 Weather Limitations

405.06 Bituminous Material Preparation
405.07 Aggregate Preparation
405.08 Mixing
405.09 Hauling
405.10 Bituminous Pavers
405.11 Rollers
405.12 Conditioning Existing Surface
405.13 Spreading and Finishing
405.14 Compaction
405.15 Joints
405.16 Spreading and Surface Tolerances
405.17 Method of Measurement
405.18 Basis of Payment

405.01 Description. This work consists of constructing 1 or more courses of aggregate and bituminous material mixed in a central or traveling plant, spread and compacted on a prepared surface.

The general plant mix specifications, 401, shall apply; deviations from these are as follows.

405.02 Composition. Use Nos. 57, 67 or 8 size aggregate for the mixture as specified. Use Nos. 8 or 9 size aggregate for choke as specified.

For material mixed by travel plant, the Engineer will adjust the estimated quantity of bituminous material to be added to the aggregate to produce a satisfactory mixture.

To adequately fill the surface voids without excess, the Engineer may adjust the estimated quantity of aggregate to be applied as choke on the surface of the compacted mixture.

The Engineer will base acceptance of the mixture on observed uniformity of mixing and coating of the aggregate particles.

405.03 Materials. Bituminous material of the type and grade specified shall meet the applicable requirements of Item 702. When 2 or more grades of one type of bituminous material are specified, the Engineer will determine the grade to be used.

The City may take pavement samples according to 106.02.

The Contractor may use coating agents conforming to AASHTO T 59 with the prior approval of the Engineer.

405.04 Mixing Plants. To prepare the bituminous mixture, the Contractor may use mixing plants of either the stationary batch or continuous type or the traveling continuous type. Obtain the Engineer's approval for the mixing plants prior to preparation of the mixtures. General requirements for bituminous concrete mixing plants are on file with the Laboratory.

405.05 Weather Limitations. Do not place bituminous cold mix under any of the following conditions: (a) when the surface is wet, (b) when the air temperature is below 40° F, or (c) when weather conditions otherwise prevent proper handling, finishing, or curing of the mixture.

405.06 Bituminous Material Preparation. Deliver bituminous material to the mixer at a uniform temperature within the range specified in Item 702.

405.07 Aggregate Preparation. Deliver aggregate to the mixer at a temperature of not less than 40° F and in a surface dry condition, except as follows.

When asphalt emulsions are used in the mixture, maintain any aggregate surface moisture that may be present, uniformly within such limits so as to obtain an acceptable coating of bituminous material.

The Contractor may treat specified liquid grades of asphalt with a coating agent. When use of such an agent is approved by the Engineer, aggregate surface moisture may be present only to the extent that the treated bituminous material will form an acceptable coating during the mixing process.

405.08 Mixing. Proportion aggregate and bituminous material and mix for the directed time so as to produce a mixture having a uniform distribution of the bituminous material and coating of the aggregate.

405.09 Hauling. Haul the bituminous mixture using trucks conforming to 401.11.

405.10 Bituminous Pavers. Use bituminous pavers for placing central mixed material conforming to 401.12. Provide spreading, leveling and strike off equipment for the traveling plant conforming to 405.04.

405.11 Rollers. Use rollers conforming to 401.13. Use a minimum of 2 rollers of the types listed, except in small areas a single tandem roller may be used. The capacity of each roller shall be considered to be 30 tons of aggregate placed per hour for steel wheel rollers and 60 tons per hour for pneumatic tire rollers. For this work, pneumatic tire rollers shall have an average tire contact pressure of not less than 55 psi and the tire contact area requirement does not apply.

405.12 Conditioning Existing Surface. Condition the existing surface according to 401.14, except that painting or coating of contact surfaces shall not be required.

405.13 Spreading and Finishing. Spread and finish the mixture according to 401.15, except place the aggregate at the weight per square yard specified.

Immediately following the initial rolling, apply the choke aggregate uniformly with adjustable, hopper equipped, revolving drum type spreaders at the specified rate or as directed by the Engineer.

Should a delay in choke application occur that would prevent adequate bonding, the Engineer may require a light application of the bituminous material used in the mix prior to the application of the choke aggregate.

405.14 Compaction. Compact the mixture according to 401.16. The Engineer may delay rolling to avoid lateral displacement. Continue final rolling until the choke aggregate is thoroughly embedded and roller marks are eliminated.

405.15 Joints. Construct joints as specified in 401.17.

405.16 Spreading and Surface Tolerances. Meet the spreading and surface tolerances specified in 401.19. The variation of the surface from the testing edge of the 10 foot straightedge shall not exceed 3/8 inch.

405.17 Method of Measurement. The City will measure aggregate and bituminous material according to Item 109. The City will measure aggregate by weight in tons.

When the mixture is prepared in a stationary plant, the City will use batch or truck weights of the mixture to compute the aggregate weight by deducting the weight of bituminous material in the mixture.

405.18 Basis of Payment. The City will pay for accepted quantities of bituminous cold mix, complete in place, at the contract prices as follows:

Item	Unit	Description
405	Ton	Mix Aggregate
405	Ton	Choke Aggregate
405	Gallon	Mix Bituminous Material

ITEM 407 TACK COAT

407.01 Description
407.02 Materials
407.03 Equipment
407.04 Weather Limitations
407.05 Preparation of Surface
407.06 Application of Asphalt Material
407.07 Method of Measurement
407.08 Basis of Payment

407.01 Description. This work consists of preparing and treating a paved surface with asphalt material, and cover aggregate if required.

407.02 Materials. Conform to the applicable requirements of Item 702 for the asphalt material and use one of the following types: 702.04 RS-1, SS-1, SS-1h, CRS-1, CSS-1, or CSS-1h; 702.12 Non-Tracking Asphalt Emulsion or 702.13 SBR Asphalt Emulsion.

Supply 702.12 Non-Tracking Asphalt Emulsion any time Item 407 Non-Tracking Tack Coat is specified.

Conform to 703.06 for cover aggregate.

407.03 Equipment. Provide adequate cleaning equipment, spreader boxes, and distributors.

Use distributors designed, equipped, maintained, and operated to apply asphalt material at the specified rate per square yard with uniform pressure over the required width of application. Ensure that the distributor includes a tachometer, pressure gauges, and an accurate volume measuring device or a calibrated tank. Mount an accurate thermometer with a range covering the specified application temperature for asphalt material at approximately center height of the tank with the stem extending into the asphalt material. Ensure that the distributor has a full-circulating system with a spray bar that is adjustable laterally and vertically. Ensure that the spray bar will maintain a constant height above the pavement under variable load conditions. Supply each distributor with suitable charts showing truck and pump speeds and other pertinent application data necessary to obtain the required results.

Do not use equipment that cannot obtain the correct tack application.

407.04 Weather Limitations. Do not apply the asphalt material if the surface temperature is below the minimum placement temperature for the pavement course to be placed, as specified in 401.06.

407.05 Preparation of Surface. Ensure that the surface is thoroughly clean and dry to the Engineer's acceptance before the asphalt material is applied. Remove material cleaned from the surface and dispose of it as the Engineer directs.

When tack material is being applied, protect the exposed surfaces of the curb and gutter and all structures from being marred or defaced.

407.06 Application of Asphalt Material. Uniformly apply the asphalt material with a distributor having clean nozzles functioning properly.

For irregular areas such as driveways and intersections, apply the asphalt material using a method the Engineer approves.

If paving asphalt concrete directly onto Roller Compacted Concrete, portland cement concrete or brick pavement, tack the pavement with SBR asphalt emulsion conforming to 702.13.

Apply the asphalt material in a manner that offers the least inconvenience to traffic. Only apply the asphalt material to areas that will be covered by a pavement course during the same day. Ensure the tack breaks before releasing to construction traffic unless the paver is equipped with a spray bar system to apply tack just prior to mat placement.

Apply asphalt material to obtain uniform coverage within the range specified in Table 407.06-1, as directed by the Engineer. Obtain the Engineer's approval for the quantity, rate of application, temperature, and areas to be treated before application of the asphalt material. The Engineer will determine the actual application in gallons per square yard by a check on the project.

TABLE 407.06-1 TYPICAL TACK COAT APPLICATION RATES

Existing Pavement	Application Rate gal/yd^2
New Asphalt	0.05 to 0.06
Oxidized Asphalt	0.08 to 0.09
Milled Asphalt Surface	0.08 to 0.09
Milled PCC Surface	0.06 to 0.08
PCC Surface	0.06 to 0.08

The application is considered satisfactory when the actual rate is within ±10 percent of the required rate and the material is applied uniformly with no visible evidence of streaking, ridging or pickup by construction traffic. The Engineer will require proper correction when ridging, streaking, pickup or other non-uniform coverage is observed. Correct non-uniform tack only in areas of non-uniform coverage. Do not reapply tack in areas where the tack meets uniformity and application requirements.

If the coverage is not uniform and not corrected the total square yardage of non-uniform application will be considered non-specification material. The Engineer will determine the number of gallons for non-payment by using the approved rate of application times the total square yards of non-uniform application.

The application rates for the non-tracking tack coats shall be the same as regular tack.

407.07 Method of Measurement. The City will measure Tack Coat and Non-Tracking Tack Coat by the number of gallons of undiluted asphalt material applied for each according to Item 109.

407.08 Basis of Payment. The cost of cover aggregate is incidental to Tack Coat.

The City will not pay for non-uniformly applied materials as defined in 407.06.

The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
407	Gallon	Tack Coat
407	Gallon	Non-Tracking Tack Coat
407	Tons	Cover Aggregate

ITEM 408 PRIME COAT

408.01 Description
408.02 Asphalt Material
408.03 Cover Aggregate
408.04 Weather Limitations
408.05 Equipment
408.06 Preparation of Surface
408.07 Application of Asphalt Material
408.08 Application of Cover Aggregate
408.09 Method of Measurement
408.10 Basis of Payment

408.01 Description. This work consists of preparing and treating an existing surface with asphalt material, and cover aggregate if required.

408.02 Asphalt Material. Conform to the applicable requirements of Item 702 for asphalt material and use one of the following types: 702.02 MC-30, MC-70, or MC-250; or 702.03 Primer 20.

408.03 Cover Aggregate. Use cover aggregate conforming to No. 9 size or gradation requirements of 703.05 or 703.06.

408.04 Weather Limitations. Do not apply asphalt material on a wet surface, or when rain is forecasted within 24 hours after applying the asphalt material. Do not apply prime coats for asphalt concrete or surface treatment work when the atmospheric temperature is below 50 °F or when the air temperature within the preceding 24 hours has been 40 °F or lower. Do not apply prime coats on stabilized or granular base courses when the atmospheric temperature is below 40 °F.

408.05 Equipment. Use equipment conforming to 407.03.

408.06 Preparation of Surface. Shape the surface to be primed to the required grade and section. Ensure the surface is free from all ruts, corrugations, segregated material or other irregularities and is smooth and uniformly compacted at the time of application of the asphalt material. Clean the surface in a manner that will thoroughly remove all mud, earth, and other foreign material. Take care to clean the edges of road to be primed to ensure uniform application of the asphalt material directly onto the existing base or pavement surface. Remove material cleaned from the surface and dispose of it as the Engineer directs.

When bituminous material is being applied, protect the exposed surfaces of the curb and gutter and all structures from being marred or defaced.

408.07 Application of Asphalt Material. Apply asphalt material in a uniform manner spread to the width of the section to be primed by means of a distributor conforming to 407.03. Take care that the application of asphalt material at the junction of spreads is not in excess of the specified amount. Squeegee excess asphalt material from the surface. Correct skipped areas or deficiencies.

Do not allow traffic on the prime coat until the asphalt material has been absorbed by the surface and will not be picked up. Obtain the Engineer's approval for the quantity, rate of application, temperatures and areas to be treated before application of the prime coat.

408.08 Application of Cover Aggregate. If, after applying the prime coat, the asphalt material fails to penetrate and traffic must use the roadway, spread cover aggregate in the amount required to absorb any excess asphalt material.

408.09 Method of Measurement. The City will measure Prime Coat by the number of gallons according to Item 109.

408.10 Basis of Payment. The cost of cover aggregate is incidental to Prime Coat.

The City will pay for accepted quantities, complete in place, at the contract price as follows:

Item	Unit	Description
408	Gallon	Prime Coat

ITEM 409 SAWING AND SEALING ASPHALT CONCRETE PAVEMENT JOINTS

409.01 Description
409.02 Materials
409.03 Construction Details
409.04 Method of Measurement
409.05 Basis of Payment

409.01 Description. This work consists of saw cutting and sealing the finished surface of the asphalt concrete pavement and shoulders directly over and in line with transverse joints in the underlying portland cement concrete pavement.

409.02 Materials. Use joint sealant conforming to 705.04 and approved by the Laboratory before shipment to the project.

409.03 Construction Details. Saw cut, clean, and seal transverse joints as a continuous operation. If the surface course is not placed within 5 days after the intermediate course is placed, make a 1/8-inch wide saw cut that is one-fourth the depth of the intermediate course over contraction joints and a 1/2-inch wide cut that is one-fourth the depth of the intermediate course over expansion joints.

Saw joints in the surface course as soon as the saw can be operated without damaging the asphalt concrete, but no later than 48 hours after the asphalt concrete is placed.

Locate the sawed joints directly over each transverse pavement joint in the concrete pavement, including joints at full-depth pavement repairs. Accurately locate joints with pins or stakes before paving. Pre-mark the saw cut on the new asphalt with a chalk line or other acceptable method. Obtain the Engineer's approval of the method for locating and accurately marking the proposed saw cuts before starting any resurfacing operations.

Saw all transverse joints and create a joint sealant reservoir according to Table 409.03-1. Use either dry or wet cutting. Make one or two passes to create the saw cut and joint sealant reservoir.

TABLE 409.03-1

Measurement	Inch
Saw cut depth	2
Joint sealant reservoir	
Width	3/8
Depth	3/4
Recess below surface course	1/8

Clean dry sawed joints with compressed air to remove dirt, dust, or deleterious matter. Use an air compressor with a minimum rated capacity of 100 pounds per square inch and sufficient hose for continuous cleaning operations.

Clean wet sawed joints with a water blast to remove sawing slurry, dirt, or deleterious matter. Dry wet sawed joints with a propane torch or lance unit capable of producing a blast of hot air at 2000 °F and with a gas velocity of 2000 feet per second.

Extend the transverse saw cut joints the full width of the asphalt over the concrete pavement and paved shoulders.

Do not allow traffic to knead together or damage the sawed joints before sealing.

Heat joint sealant material in a kettle or melter constructed as a double boiler, with the space between the inner and outer shells filled with oil or other heat transfer medium. Provide positive temperature control and mechanical agitation.

Heat the material according to the manufacturer's recommendation. Consider the first gallon of material that flows out of the applicator wand at the start of the day spoil, and discard it into a container so designated.

After cleaning, immediately seal the joints with sealant applied through a nozzle projected into the sawed joint, filling from the bottom up. Ensure that the sealant completely fills the joint such that after cooling, the level of the sealant is below the surface by less than 1/8 inch). Fill any depression in the seal greater than 3/16 inch to the specified limit by adding additional sealant. Do not overfill the joints. Take care in the sealing of the joints so that the final appearance will present a neat line.

409.04 Method of Measurement. The City will measure Sawing and Sealing Asphalt Concrete Pavement Joints by the number of feet of joints sawed and sealed.

409.05 Basis of Payment. The City will not pay for saw cuts in the intermediate course.

The City will pay for accepted quantities at the contract price as follows:

Item	Unit	Description
409	Foot	Sawing and Sealing Asphalt Concrete Pavement Joints

ITEM 410 TRAFFIC COMPACTED SURFACE

410.01 Description
410.02 Materials
410.03 Conditioning of the Subgrade
410.04 Spreading and Shaping
410.05 Maintaining
410.06 Method of Measurement
410.07 Basis of Payment

410.01 Description. This work consists of furnishing and placing an aggregate wearing course on the completed and accepted subgrade or temporary road.

410.02 Materials. Furnish materials conforming to 703.18 for the type of material specified (Type A, Type B, or Type C).

410.03 Conditioning of the Subgrade. Eliminate wavy and irregular surfaces and maintain the subgrade in this condition until the application of material under this item. If the subgrade is soft due to rain, frost, or snow, place material only as permitted.

410.04 Spreading and Shaping. Uniformly spread the material using an approved spreader box or by other methods. Spread the amount of material shown on the plans or as directed by the Engineer. After spreading, blade and shape the materials to the specified cross-sections. Haul the material to its place on the road over the previously spread material. Conduct the hauling to obtain uniform compaction over the entire width of the surface material without rolling.

410.05 Maintaining. After shaping the material, blade it as directed by the Engineer. Open the road to traffic immediately after all the material has been spread and shaped.

Correct all holes, ruts, defects, or soft places that occur in the subgrade or surface by adding material and dragging. Maintain the surface, slopes, shoulders, ditches, and drainage structures until the work on this item has been completed and accepted.

410.06 Method of Measurement. The City will measure Traffic Compacted Surface, Type ___ by the number of cubic yards or tons of accepted material placed, shaped, and maintained as specified.

The City will measure the cubic yards of aggregate used loose in the vehicle at the point of delivery or calculate it by converting from weight using the following conversion factors:

TABLE 410.06-1

Material	Conversion Factor
Gravel, bank run or crusher run	2700 lb/yd^3
Limestone, crusher run	2500 lb/yd^3
Gravel, Size No. 4 and 57	2500 lb/yd^3
Limestone, Size No. 4 and 57	2400 lb/yd^3
Crushed slag [1]	
less than 80 lb/ft^3	2000 lb/yd^3
80 to 90 lb/ft^3	2100 lb/yd^3
90.1 to 100 lb/ft^3	2300 lb/yd^3
100.1 to 125 lb/ft^3	2700 lb/yd^3
more than 125 lb/ft^3	3000 lb/yd^3
Recycled Portland Cement Concrete	2250 lb/yd^3
Recycled Asphalt Pavement	2650 lb/yd^3
[1] Based on average dry rodded weight determined by the Laboratory. The conversion factors listed are the long gradation weights. These numbers are based on the dry rodded weights of Nos. 67, 57, or 8 gradation. The City will determine slag weights based on weights obtained from the original source.	

The City will classify salvaged or mixed materials according to the material that makes up the majority of the mixture.

Ensure that the moistures of the delivered material are less than 2 percent above saturated surface dry condition; if not, the City will base payment on the dry densities and dry weights.

Furnish freight bills, and weight and volume evidence according to Item 109.

410.07 Basis of Payment. The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
410	Cubic Yard or Ton	Traffic Compacted Surface, Type A or B
410	Cubic Yard or Ton	Traffic Compacted Surface, Type C

ITEM 411 STABILIZED CRUSHED AGGREGATE

411.01 Description
411.02 Materials
411.03 Construction Methods
411.04 Method of Measurement
411.05 Basis of Payment

411.01 Description. This work consists of placing a compacted course or courses of crushed aggregate.

411.02 Materials. Furnish materials conforming to 703.18.

411.03 Construction Methods. Construct the subgrade according to Item 204. Use the spreading and compaction requirements of Item 304, except as modified by the following:

A. Use a maximum compacted lift thickness of 6 inches.

B. Perform the initial compaction of the material by using crawler type tractors, tamping rollers, trench rollers, suitable pneumatic tire equipment, or other suitable equipment.

C. Perform final compaction of the surface of the stabilized crushed aggregate by using approved pneumatic tire equipment.

Unless otherwise specified in the Contract Documents, the Engineer will perform all compaction tests according to Supplemental Specification 1501.

411.04 Method of Measurement. The City will measure Stabilized Crushed Aggregate by the number of cubic yards, computed from the profile grade, cross-sections and typical sections, compacted in place.

When the plans provide for the use of material in variable width or depth of course and the quantity cannot be readily calculated from the profile grade, typical sections and cross-sections, the City will measure the cubic yards by converting from weight using the following conversion factors:

TABLE 411.04-1

Material	Conversion Factor
Crushed stone	3800 lb/yd^3
Crushed gravel	3900 lb/yd^3
Crushed slag [1]	
less than 90 lb/ft^3	3600 lb/yd^3
90 to 100 lb/ft^3	4000 lb/yd^3
more than 100 lb/ft^3	4500 lb/yd^3
Granulated slag	2800 lb/yd^3
Recycled Portland Cement Concrete	3400 lb/yd^3
Recycled Asphalt Pavement	4000 lb/yd^3

[1] Based on average dry rodded weight of standard size of slag aggregates on record at the Laboratory. The conversion factors listed are the long gradation weights. These numbers are based on the dry rodded weights of Nos. 67, 57, or 8 gradation. The City will determine slag weights based on weights obtained from the original source.

The City will classify salvaged or mixed materials according to the material that makes up the majority of the mixture.

Ensure that the moistures of the delivered material are less than 2 percent above saturated surface dry condition; if not, the City will base payment on the dry densities and dry weights.

Furnish freight bills or certified weight bills according to Item 109.

411.05 Basis of Payment. The City will pay for accepted quantities at the contract price as follows:

Item	Unit	Description
411	Cubic Yard	Stabilized Crushed Aggregate

ITEM 412 SEAL COAT

412.01 Description
412.02 Bituminous Material
412.03 Cover Aggregate Material
412.04 Weather Limitations
412.05 Equipment
412.06 Preparation of Surface
412.07 Protection of Curbs and Structures
412.08 Applying Bituminous Material
412.09 Cover Aggregate
412.10 Method of Measurement
412.11 Basis of Payment

412.01 Description. This work consists of constructing a wearing surface composed of 1 or more applications of bituminous material and cover aggregate, in place and compacted.

412.02 Bituminous Material. Furnish bituminous material, of the type and grade specified, conforming to Item 702. When 2 or more grades of one type of bituminous material are specified in the contract, the Engineer will determine the grade to be used.

412.03 Cover Aggregate Material. Use cover aggregate conforming to 703.05. The sizes of aggregate shall be No. 6, No. 67, No. 8 or No. 9, as specified. The surface moisture of the cover aggregate shall not exceed that which will permit the proper coating and adhesion of the type of bituminous material specified, except that the Contractor may treat the bituminous material with an agent, conforming to AASHTO T 59, that will assist in obtaining sufficient coating to hold the aggregate in place, provided the Engineer approves such treatment.

412.04 Weather Limitations. Do not apply bituminous material when the temperature of the atmosphere is below 60° F nor when the air temperature within the preceding 24 hours has been below 40° F. Do not apply emulsified asphalt 401.09 between October 1 and May 15 of the succeeding year except by permission of the Engineer. Do not apply bituminous material while the surface is wet or when the humidity or impending weather conditions are such that proper curing may not be obtained. The Contractor may apply emulsified asphalt to a damp surface with the Engineer's approval.

412.05 Equipment. Use bituminous distributors conforming to 407.03. Use pneumatic tire roller conforming to 401.13. Inflate tires to a pressure producing a minimum average contact pressure of 55 psi.

When using pneumatic tire rollers on a seal coat with Item 405, use in conjunction with three-wheeled rollers conforming to 401.13.

Use either self-propelled or truck mounted aggregate spreaders, equipped with hoppers, revolving cylinders and adjustments necessary to produce a uniform distribution of particles at the specified rate.

412.06 Preparation of Surface. Clean the pavement according to 407.05.

412.07 Protection of Curbs and Structures. When applying bituminous material, protect the exposed surfaces of curbs, curb and gutter or other structures from being marred or defaced.

412.08 Applying Bituminous Material. Use a pressure distributor to apply the bituminous material, heated to a temperature within the specified range. Apply the material with sufficient uniformity to prevent ridging or streaking in the completed surface. The Contractor may adjust the rate of application specified in the contract with the approval of the Engineer when necessary to result in satisfactory embodiment and retention of the cover aggregate.

At the beginning and at the end of a contract section, start and stop the application on paper or other suitable material sufficiently wide enough to permit full application on the surface being treated. Make transverse and longitudinal laps in such a manner that the texture of the finished surface will be uniform and continuous.

Prior to starting the application of bituminous material, ensure sufficient cover aggregate is available for immediate application.

412.09 Cover Aggregate. Immediately following the application of the bituminous material, apply cover aggregate uniformly without ridges or laps at the specified rate adjusted as directed by the Engineer to produce a minimum of excess loose particles. Spread aggregate in such manner that the tires of the truck or aggregate spreader at no time contact the uncovered and newly applied bituminous material. Prior to rolling, correct deficiencies in the application of cover aggregate in a manner satisfactory to the Engineer.

Begin rolling immediately behind the spreader and perform 4 complete coverages. When three-wheeled rollers are required, use them for at least the initial coverage. A roller coverage shall consist of 2 trips or passes over the same area. Do not operate rollers at speeds that cause pick up or dislodging of aggregate particles.

Following the completion of rolling, protect the surface from traffic damage during the period of time required for the bituminous material to cure sufficiently to prevent dislodging of the aggregate particles by normal traffic. During this period, correct deficiencies in cover aggregate by spreading additional aggregate or by light brooming as directed by the Engineer.

Sweep excess cover aggregate from the surface by means of rotary brooms soon after the bituminous material has cured sufficiently to prevent dislodging of the embedded aggregate particles.

412.10 Method of Measurement. The City will measure the number of tons of aggregate and the gallons of bituminous material in place, completed and accepted, according to Item 109.

412.11 Basis of Payment. The City will pay for accepted quantities, complete in place, at the contract prices as follows:

Item	Unit	Description
412	Gallon	Seal Coat Bituminous Material
412	Ton	Seal Coat Cover Aggregate

ITEM 417 ASPHALT EMULSION SLURRY SEAL

417.01 Description
417.02 Materials
417.03 Equipment
417.04 Preparation of Surface
417.05 Composition and Rate of Application of the Slurry Mix
417.06 Weather Limitations
417.07 Traffic Control
417.08 Application of the Slurry Surfaces
417.09 Acceptance
417.10 Documentation
417.11 Method of Measurement
417.12 Basis of Payment

417.01 Description. This work consists of constructing a slurry seal composed of a mixture of emulsified asphalt, mineral aggregate, and water; properly proportioned, mixed, and spread evenly on the surface as specified herein and as directed by the Engineer. The cured slurry shall have a homogeneous appearance, fill all cracks, adhere firmly to the surface and have a skid resistant texture.

417.02 Materials.

A. Asphalt Emulsion. Furnish emulsified asphalt conforming to AASHTO specifications for dense mixing grade SS-1h except that they shall be of the QUICK SET SLURRY SEAL EMULSION TYPE, either anionic or cationic, whichever in the opinion of the Engineer and the Laboratory is best suited to the aggregates and job conditions to be encountered. The following specifications will apply:

TABLE 417.02-1

	Quick Set Anionic	Quick Set Cationic
Viscosity at 77° F, SSF, secs.	15-50	15-50
Residue from Distillation Weight, %	57% min.	57% min.
Sieve Test, Retained on 20 mesh, %	0.10 max.	0.10 max.
Particle Charge, Electroplate	Negative	Positive
Tests on Residue from Distillation:		
Penetration at 77° F, 100 G., 5 sec.	40-90	40-90
Solubility in CS2 or TCE	97.5 min.	97.5 min.
Ductility at 77° F, cm.	40 min.	40 min.
Tests on Job Design Slurry:		
Mixing Time Test Sec.	120 min.	120 min.
Set Time Blotter Test, 30 mins.	No brown stain or displacement	No brown stain or displacement
Water Resistance Test, 30 mins.	No - discoloration	No - discoloration
Coating Test (3 min. in boiling water), %	90 min.	90 min.
Wet Track Abrasion Test, Loss in gms. per sq. ft.	75 max.	75 max.
Loaded Wheel Test, Sand Adhesion gms. per sq. ft.	60 max.	60 max.

B. Aggregate. Furnish mineral aggregate consisting of 100 percent crushed gravel, or slag, or approved limestone and that is clean and free from vegetable matter and other deleterious substances. When tested by AASHTO T176, the aggregate blend shall have a sand equivalent of not less than 45. When tested according to AASHTO T104, the aggregate shall show a loss of not more than 35 percent.

Consider mineral fillers such as portland cement or limestone dust as part of the blended aggregate and use in minimum required amounts. Ensure mineral fillers meet the gradation requirements of ASTM D242 (Dry). Only use mineral fillers if needed to improve the workability of the mix or gradation of the aggregate.

Only use aggregates in the work that have a proven durability record for the conditions and traffic expected. The Engineer will approve the aggregate source before work proceeds. The combined mineral aggregate shall conform to the following gradation when tested by the previously mentioned test, ASTM D242 / D242M:

TABLE 417.02-2

Sieve Size	Type A (Slurry Seal) Percent Passing
3/8	100
No. 4	85-100
No. 8	50-80
No. 16	40-65
No. 30	25-45
No. 50	13-25
No. 100	--
No. 200	5-15
Theoretical Asphalt Content,	7.5-13.5
(% Dry Aggregate) % Extracted from dry sample	
Application Rate,	
Aggregate lbs./SY, Dry	16 (min.)

C. Water. Only use potable water that is free from harmful soluble salts, with the slurry mixture.

D. Stockpiling of Aggregate. Do not stockpile at areas other than the quarry site without the Engineer's approval. Stockpile in a manner that prevents contamination and segregation of the aggregate.

E. Storage. Provide suitable storage facilities for the asphalt emulsion. Equip the container to prevent water from entering the emulsion. Provide suitable heat if necessary to prevent freezing.

F. Sampling. Provide samples of materials as directed by the Engineer during progress of the work. The Engineer may request test reports as additional materials arrive.

G. Design. Submit to the Engineer a complete laboratory design made in a qualified laboratory at least 7 days prior to start of work. Perform a complete analysis of the materials and JMF proposed for use in the performance of the work in accordance with procedures outlined in the current issue of International Slurry Seal Association Technical Bulletin No. 111 as indicated by the Engineer. The Engineer will review and approve the selection of the optimum mix design from the material data presented.

H. Submittals. Submit along with the required written materials analysis and proposed JMF the following physical specimens, if requested by the Laboratory:

1. 11 lb of the proposed aggregate selected.
2. 1 gal of the proposed emulsion selected.
3. 1 lb of the filler selected, if applicable.
4. 3 series of consistency tests at 100, 85 and 70 percent BR and at 2-3, 4-5, and 6-7 cm. consistencies.
5. 2 each of abraded Wet Tract Abrasion Test specimens at 100, 85 and 70% BR.
6. 2 each of sand adhered Loaded Wheel Test specimens at 100, 85 and 70% BR.

Identify each specimen indelibly with the date and source.

The Engineer may waive the design submittals provided the Contractor has previously applied, in accordance with 417.02.H, a satisfactorily designed and applied slurry with substantially the same materials proposed for this work. In any case, the Contractor may not introduce untried materials into this work without complete analysis and design of a JMF for each new material and the approval of the Engineer.

417.03 Equipment. Maintain all equipment, tools, and machines used in the performance of this work in satisfactory working order at all times. Before mix production, calibrate the mixing equipment in the presence of the Engineer. Generate documentation for the Engineer, including individual calibrations of each material at various settings. Perform a new calibration if there is any change in the mix design. Supply all of the equipment, materials, and scales necessary to perform the calibration. Following calibration and adjustments for changes in the mix design, do not make any further calibration adjustments to the mixing equipment without the Engineer's approval.

A. Slurry Mixing Equipment. Use a continuous flow mixing unit, capable of delivering accurately a predetermined proportion of aggregate, water and asphalt emulsion to the mixing chamber and discharging the thoroughly mixed product on a continuous basis. Pre-wet the aggregate immediately prior to mixing with the emulsion. Ensure that the mixing unit of the mixing chamber is capable of thoroughly blending all ingredients together. Do not allow any violent mixing. Equip the mixing machine with an approved fines feeder that provides an accurate metering device or method to introduce a predetermined proportion of mineral filler into the mixer at the same time and location that the aggregate is fed. Use the fines feeder whenever added mineral filler is a part of the aggregate blend.

Equip the mixing machine with a water pressure system and fog type spray bar adequate for completing fogging the surface preceding spreading equipment with a maximum application of 0.05 gallons per square yard. Do not carry free water in front of the spreader. Equip the emulsion tanks with some type of measuring device that will provide a quick reference to determine application rate in gallons of emulsion per square yard. Use a minimum of two complete slurry machines of at least 10 tons aggregate capacity each to provide as nearly a continuous operation as possible.

B. Slurry Spreading Equipment. Attach to the mixing machine a mechanical type squeegee distributor box equipped with flexible material to contact with the surface to prevent loss of slurry from the spreader box. To prevent the loss of slurry on varying grades and crowns, adjust the spreader box to ensure a uniform spread.

Provide a steering device and a flexible strike-off. The spreader box shall have an adjustable width. Keep the box clean, and prevent build-up of asphalt and aggregate on the box. Use burlap drags or other drags with the Engineer's approval.

C. Cleaning Equipment. Use power brooms, power blowers, air compressors, water flushing equipment, and hand brooms to clean the surface and cracks of the old surface. Only use high pressure water (10 gal/m at 1,000 psi) to remove mud and adhesive clays.

D. Auxiliary Equipment. Provide hand squeegees, shovels, and other equipment as necessary to perform work.

417.04 Preparation of Surface. Perform sweeping, weed removal and final cleaning just before the machine. The Contractor may use any standard cleaning method to clean pavements, except water flushing will not be permitted in areas where considerable cracks are present in the pavement surface. The Engineer will give final approval of the surface.

If the slurry is being placed over a brick or concrete surface, highly absorbent asphalt surface, or over a surface where the aggregate has become exposed and is polished and slick, the Contractor may apply, with the asphalt distributor, a one part emulsion, three parts water, tack coat of the same asphalt emulsion type and grade as specified for the slurry. The normal application rate is 0.03 to 0.06 gallons of the diluted emulsion per square yard of surface. Do not proceed without the Engineer's final approval.

417.05 Composition and Rate of Application of the Slurry Mix. Translate the optimum JMF as set forth in the materials section of this specification into job control quantities in accordance with ISSA TB #107.

The slurry seal mixture shall be of proper consistency at all times so as to provide the application rate required by the surface condition. The average application rate, as measured, shall be in accordance with the following table.

Aggregate Type	Application	Application Rate
Type A	Urban and Residential Streets	16 lb/yd^2 Minimum

The application rate is based upon the weight of dry aggregate in the mixture. The application rate is affected by the unit weight of the aggregate, the gradation of the aggregate and the demand of the surface to which the slurry seal is being applied. ISSA TB #112 gives a method to determine expected application rates.

Control the consistency of the mix to within 2.5 and 3.5 cm.

Maintain a complete daily record of the quantities and make available to the Engineer or City representative upon request. The City will not make final payment for the work until all load tickets and inventories are verified to ensure that specification quantities have been applied. In case of disputes, the Engineer's judgment will be final.

417.06 Weather Limitations. The Contractor may apply the mixture when both the air and pavement temperature are 45° F or above and rising.

417.07 Traffic Control. Use suitable methods such as pennants, barricades, flaggers, and pilot cars to protect the uncured slurry surface from all types of traffic. Any damage to the uncured slurry will be the responsibility of the Contractor. The Engineer will give final approval as to the method used. If damage occurs where suitable means have been made to protect the uncured slurry, the City will prosecute violators and reimburse the Contractor for the amount of the damages. Notify residents affected by the work in writing, 1 week before the work is to be done. Post "No Parking" signs 3 working days before the work is to be done. Tow parked vehicles after 3 days of notification, assuming responsibility and liability for the removal of these vehicles.

417.08 Application of the Slurry Surfaces.

A. General. Fog the surface with water directly preceding the spreader. Ensure that the slurry mixture is of the desired consistency when deposited on the surface; do not add additional elements. Total time of mixing shall not exceed 4 minutes. Ensure that a sufficient amount of slurry is carried in all parts of the spreader at all times so that complete coverage is obtained. Do not allow lumping, balling, or unmixed aggregate, or excessive breaking of the emulsion in the spreader box. Do not leave any streaks such as caused by oversized aggregate in the finished pavement.

B. Joints. Do not allow excessive build-up or unsightly appearance on longitudinal or transverse joints.

C. Hand Work. The Contractor may use approved squeegees to spread slurry in areas inaccessible to the slurry mixer. Take care to leave no unsightly appearance from hand work. In areas with adjacent concrete curb or curb and gutter which are not to be treated, use special care to avoid covering the concrete. If the Engineer determines that insufficient care is being taken to protect the concrete, the Engineer may require masking with suitable material at no additional cost to the City.

D. Curing. Before opening to traffic, allow treated areas to adequately cure until such time as the slurry seal will not be damaged by traffic.

E. Structures. Prior to the work, mask all structures that may become marred by the slurry, such as open gates, catch basins, manholes and valve boxes, with 0.006 inches plastic or equal and attached so as not to be displaced by the operations. Remove masking material after the slurry has cured. To achieve a clean straight line at intersections, use 15 pound roofing felt or equal as directed by the Engineer. Remove all masking materials at the completion of the work.

417.09 Acceptance. The Engineer will inspect the project with the Contractor for surface flushing and loss of material. If these deficiencies are found, corrective work is required. The Engineer will base acceptance of the slurry seal on the minimum required application rate.

Complete all corrective work within seven working days of the review, or by an agreed date. All costs associated with completing this corrective work, to the satisfaction of the Engineer, will be paid for by the Contractor.

417.10 Documentation. Provide a Summary of Slurry Seal Quantities - Yield Report for each worksheet to the Engineer, within one working day, with the following information:

- Control Section, Project Name, Street Name, County, Engineer
- Date, Time and Air Temperature
- Control Settings (From Calibration), Calibration Values (lbs/count)
- Unit weight of emulsion (lbs/gal), % residue in emulsion
- Beginning and ending stations of project
- Counter readings for Cement, Emulsion and Aggregate (beginning, ending and total)
- Length (Ft), width (Ft), area (Sq.Yd), weight of aggregate placed (lbs) and weight of emulsion placed (lbs)
- % of each material, percent of asphalt cement, application rate
- JMF (% portland cement, % emulsion, gradation and % A.C.)
- Contractor's authorized signature
- Contractor to calculate:
- % Cement

- % Emulsion
- Aggregate Spread Rate
- Gallons Emulsion/ Unit weight of emulsion (Lbs/gal)
- Weight of emulsion placed (Lbs)/ % residue in emulsion
- Asphalt Content

417.11 Method of Measurement. The City will measure slurry seal surface by the square yards of work completed and accepted as designated by the Engineer for each type applied.

417.12 Basis of Payment. The City will pay for accepted quantities complete in place at the contract unit price per square yard. Price and payment will be full compensation for furnishing and placing all materials. The City will not pay for any work that does not meet the specified application rate.

The City will pay for accepted quantities complete in place, at the contract price as follows:

Item	Unit	Description
417	Square Yard	Asphalt Emulsion Slurry Seal, Type A

ITEM 421 MICROSURFACING

421.01 Description
421.02 Materials
421.03 Proportioning
421.04 Weather Limitations
421.05 Mixing Equipment
421.06 Equipment Calibration
421.07 Spreading Equipment
421.08 Surface Preparation
421.09 Test Strip
421.10 Application
421.11 Acceptance
421.12 Not Used
421.13 Method of Measurement
421.14 Basis of Payment

421.01 Description. This work consists of constructing a cold laid polymer modified emulsified asphalt pavement course to fill ruts or provide a leveling and/or surface course for existing pavements.

421.02 Materials. Use a polymer modified emulsified asphalt binder (Binder) consisting of the following:

Use a quick-traffic CSS-1hM (as defined below). Use only emulsion certified per City Supplement 1032.

Do not use port addition of the polymer to the emulsified asphalt. Provide to the Engineer certified test data and a statement from the Binder manufacturer with each load of Binder that the Binder is the same formulation as used in the mix design.

Ensure the Binder meets the following and specification limits will be producible for at least 30 days from sample date:

Tests on emulsion, AASHTO T 59, unless otherwise designated:	CSS-1hM [1]
Viscosity, Saybolt Furol, at 77°F (SFS)	20 to 100
Storage Stability Tests, 24-hr (% difference), max.	1
Particle Charge Tests	Positive
Sieve Tests (%) (Distilled Water), max.	0.10
Distillation to 177 °C, Residue % solids, min [2]	62
Tests on distillation residue:	
Penetration, 25 °C, 100 g, 5 sec (dmm) AASHTO T 49	40 to 90
Ductility, 25 °C 5 cm/min, AASHTO T 51	40
Solubility in trichloroethylene, (%), min. AASHTO T 44 [3]	97.5
Elastic Recovery, 10 °C, 20 cm (%), min. AASHTO T 301 [4]	45
Softening Point, Ring & Ball (°C), min. AASHTO T 53	60

[1] Pre-blend only: Use a minimum of 3.0% SBR solids based on weight of the asphalt binder. Use Natural SBR latex modifier or synthetic SBR latex modifier conforming to 702.14. Use only one type of latex. Mill or blend the SBR Emulsion into the emulsified solution prior to the emulsification process.

[2] See ODOT Supplement 1013. For natural latex, use the Oven Evaporation method in AASHTO T 59 in place of distillation and use this residue for further testing.

[3] On the base asphalt only. Solubility in N-Propyl Bromide (ASTM D7553) can be used in place of trichloroethylene.

[4] Straight molds. Hold at test temperature for 90 minutes. Place in ductilometer and elongate 20 cm at 5 cm/min. Hold for 5 minutes and cut. After 1 hour retract the broken ends to touch and measure the elongation (X) in centimeters to the nearest 0.01 cm. Use the following formula to calculate the elastic recovery:

$$\text{Percent Recovery} = \left(\frac{20 - X}{20}\right) \times 100$$

Report Results to nearest 0.1%.

Conform to 703.01 and 703.05 for aggregate, except as follows:

Percent by weight of fractured pieces	100
Sand Equivalence (ASTM D 2419)	45 minimum

Conform to Gradation A for the aggregate for leveling and surface courses and to Gradation B for the aggregate for rut fill courses according to the following:

Sieve Size	Total Percent Passing	
	A	**B**
3/8 inch	100	100
No. 4	85 to 100	70 to 90
No. 8	50 to 80	45 to 70
No. 16	40 to 65	28 to 50
No. 30	25 to 45	19 to 34
No. 50	13 to 25	12 to 25
No. 100	–	7 to 18
No. 200	5 to 15	5 to 18

Screen the aggregate for oversize material prior to use. For mineral filler, use portland cement conforming to ASTM C 150, Type I. Use water conforming to 499.02. Use mix set additives as required.

421.03 Proportioning. Provide a mix design that has current ODOT approval. Where one does not exist, submit to the Laboratory a sample of the Binder to be used and a complete mix design prepared by an approved laboratory. Verify the compatibility of the aggregate, Binder, mineral filler, and other additives. Make the mix design with the same materials that will be used on the Project.

A. Ensure that the mix design:

1. Has aggregate meeting the gradation specified.

2. Has residual asphalt by dry weight of aggregate of 7.0 to 8.5 percent for leveling and surface courses or 6.5 to 8.0 percent for rut fill courses.

3. Has a mineral filler content of 0.3 to 3.5 percent by dry weight of aggregate.

4. Meets the specified properties of the following International Slurry Seal Association (ISSA) tests:

ISSA Test No.	Description	Specification
TB-139 (1-90)	Wet Cohesion	
	30 minutes min. (set time)	12 kg-cm min.
	60 minutes min. (traffic)	20 kg-cm min or near spin
TB-114 (1-90)	Wet Stripping	90 percent min.
TB-100 (90)	Wet Track Abrasion Loss 1-hour soak 6 day soak	 450 g/m² max. 650 g/m² max.
TB-144 (2-89)	Saturated Abrasion Compatibility	3 g loss max.
TB-113 (1-90)	Mix Time @ 25 °C	Controllable to 120 seconds
	Mix Time @ 40 °C	Controllable to 35 seconds

Check the ISSA TB-139 (set time) and ISSA TB-113 (mix time) tests at the highest temperature expected during construction. For the ISSA TB-113 test at 104 °F, preheat all ingredients and containers.

B. The JMF should report the following (all percentages are based on the dry weight of the aggregate):

1. Source of each individual material.

2. Aggregate gradation.

3. Percentage of aggregate.

4. Sand equivalence of the aggregate.

5. Percentage of mineral filler (minimum and maximum).

6. Percentage of water (minimum and maximum).

7. Percentage of mix set additives (if required).

8. Percentage of Binder and type.

9. Quantitative effects of moisture content on the unit weight of the aggregate.

421.04 Weather Limitations. Apply the mixture only when it is not raining and the existing pavement surface and atmospheric temperature is a minimum of 45 °F and rising and there is no forecast of an atmospheric temperature below 32 °F within 24 hours from the time the mixture is applied. Between September 30 and May 1, do not apply the mixture if the existing pavement surface temperature is less than 50 °F.

421.05 Mixing Equipment. Produce the mixture in a self-propelled, front feed, continuous loading mixing machine equipped with a conveyer belt aggregate delivery system and an interconnected positive displacement, water jacketed gear pump to accurately proportion aggregate and asphalt emulsion. Locate the mineral filler feed so the proper amount of mineral filler is dropped on the aggregate before discharge into the pugmill. Provide a spray bar to completely pre-wet the aggregate dropping down to the pugmill with additive and water before introduction of asphalt emulsion. Ensure that the twin-shaft, multi-blade pugmill is a continuous flow type and minimum of 49 inches long. Ensure that the blade size and side clearances meet the equipment manufacturer's recommendations. Introduce the emulsion within the first one-third of the mixer length to ensure proper mixing of all materials before exit from the pugmill.

Equip the machine with opposite side driving stations to allow full control of the machine from either side. Equip the mixer with a remote forward speed control at the back mixing platform so the back operator can control forward speed and level of mixture in the paving or rut box. Provide material control devices that are readily accessible and positioned so the amount of each material used can be determined at any time.

Equip the mixing machine with a water pressure system and nozzle type spray bar to provide a water spray ahead of and outside the spreader box when required. Apply water at a rate that will dampen the surface, but will not create free flowing water ahead of the spreader box.

The Contractor may use truck-mounted machines with a conveyer belt aggregate delivery system and without the front feed, continuous loading feature on project segments of less than 15,500 square yards on spot repairs.

421.06 Equipment Calibration. Before mix production, calibrate the mixing equipment in the presence of the Engineer. Generate documentation for the Engineer, including individual calibrations of each material at various settings. Perform a new calibration if there is any change in the mix design. Supply all of the equipment, materials, and scales necessary to perform the calibration. Following calibration and adjustments for changes in the mix design do not make any further calibration adjustments to the mixing equipment without the Engineer's approval.

421.07 Spreading Equipment. If a leveling or surface course is specified, apply the mixture uniformly by means of a conventional spreader box attached to the mixer.

If a rut fill course is specified, apply the mixture with a V-shaped rut filling spreader box attached to the mixer. Equip the rut filling spreader box with a steel strike-off.

Equip the spreader box with augers mounted on an adjustable shaft to continually agitate and distribute the materials throughout the box. Ensure that the equipment provides sufficient turbulence to prevent the mix from setting in the box or causing excessive side build-up or lumps. To prevent loss of the mixture from the box, attach flexible seals, front and rear, in contact with the road. Operate the spreading equipment in such a manner as to prevent the loss of the mixture on super-elevated curves.

For surface courses, attach a secondary strike-off to the spreader.

The Contractor may use burlap drags or other drags, if necessary, to obtain the desired finish. Replace drags having excessive build-up.

421.08 Surface Preparation. Before applying the mixture, thoroughly clean the surface.

Remove all existing pavement markings, except 740.02 (traffic paint), using an abrasion method conforming to 641.10.

If the microsurfacing is being placed over a brick or concrete surface, highly absorbent asphalt surface, or over a surface where the aggregate has become exposed and is polished and slick, the Contractor may apply a tack coat conforming to Item 407, consisting of one part asphalt emulsion and three parts water. Apply the tack coat at a rate of 0.03 to 0.06 gallon per square yard.

Remove raised pavement markers according to 621.08, when specified. The Contractor may fill the depression caused by the removal of the casting with material meeting this specification.

Remove any existing longitudinal pavement markings 740.04 (thermoplastic) and 740.07 (epoxy) using an abrasion method conforming to 641.10. Protect drainage structures, monument boxes, water valves, and similar structures during material application.

421.09 Test Strip. Construct a continuous 1000-foot long by lane width test strip consisting of the application course specified. Construct the test strip at the same time of day or night the full production will be applied.

The Engineer will evaluate the completed test strip 1 hour after application to determine if the mix design is acceptable. The Contractor may begin full production after the Engineer accepts the test strip.

If the microsurfacing is being applied between May 1 and September 30, the City will waive the test strip if the Contractor has constructed a City accepted test strip during the same timeframe with the same materials and mix design.

421.10 Application. Apply the paving mixture in a manner to fill cracks, shallow potholes, and minor surface irregularities and achieve a uniform surface without causing skips, lumps, or tears. Carry a sufficient amount of material at all times in all parts of the spreader box to ensure complete coverage. Avoid overloading of the spreader box. Do not allow lumping, balling, or unmixed aggregate in the spreader box.

If a rut fill course is specified, apply enough material to fill the wheel paths without excess crowning (overfilling). An excess crown is defined as 1/8 inch after 24 hours of traffic compaction. Apply rut fill courses in widths from 5 to 6 feet for each wheel path. Provide a smooth, neat seam where two rut fill passes meet. Take care to restore the designed profile of the pavement cross-section. Feather the edges of the rut fill course to minimize the use of excess material.

If a leveling course and a surface course are specified, apply the paving mixture at 14 ± 2 pounds per square yard for the leveling course and 16 ± 1 pounds per square yard for the surface course. Apply the two courses at a minimum combined rate of 30 pounds per square yard, regardless of the above tolerances.

If a surface course is specified and it is not placed on a Microsurfacing Leveling Course, apply the dry aggregate at a minimum of 20 pounds per square yard.

For surface courses, provide a smooth, neat seam of 1 to 3 inches where two passes meet. Leveling courses should not overlap. Immediately remove excess material from the ends of each run.

Construct surface courses wide enough to cover the outside edges of rut fill and leveling courses. Maintain straight edge lines along curbs and shoulders. Do not allow runoff in these areas. Ensure that lines at intersections are straight.

Use squeegees and lutes to spread the mixture in areas inaccessible to the spreader box and areas requiring hand spreading. The Contractor may adjust the mix set additive to provide a slower setting time if hand spreading is needed. Do not adjust the water content to adjust the setting time. If hand spreading, pour the mixture in a small windrow along one edge of the surface to be covered and spread it uniformly by a hand squeegee or lute. Provide uniform appearance of the entire surface area regardless of the means used to spread material.

Ensure that the microsurfacing cures at a rate that will permit traffic on the pavement within 1 hour after application without damaging the pavement surface. However, should the Contractor have concerns about adequate cure, work out an arrangement agreeable to the Engineer before releasing traffic on the pavement.

If there is an excessive streaking problem created by high amounts of oversize material in the mix, stop applying the mixture and take steps to correct the streaking problem. Do not resume work until the Engineer is satisfied the problem has been corrected.

421.11 Acceptance. Maintain continuous control of the binder to dry aggregate proportioning to conform to the approved mix design within a tolerance of ±2 gallons per ton. Control the spread rate to not less than the specified quantity of aggregate per square yard on a dry weight basis.

If requested by the Engineer, within one hour of start of production, obtain and label a binder and diluted tack coat sample from the distributor trucks and give the samples to the Engineer the same day. Provide and sample the binder and diluted tack coat in one quart plastic containers with plastic screw tops. Label and retain one sample of each per each additional day for the City. Take more samples when requested by the Engineer.

The Engineer will base acceptance of the binder-to-dry aggregate proportion and spread rate on the Engineer's summary of quantities used each day. The Engineer will approve and accept a day's application of microsurfacing provided:

A. The Engineer's summary indicates conformance with the above control requirements for proportioning and spread rate and

B. The pavement is free from excessive scratch marks, tears, rippling and other surface irregularities, longitudinal joints and lane edges coincide with any lane lines, and edge lines and transverse joints are uniform, neat and provide a smooth transition.

The spread rate requirement does not apply to rut fill courses if the Contractor filled the wheel paths according to this specification.

421.12 Not Used.

421.13 Method of Measurement. The City will measure Microsurfacing, Surface Course and Microsurfacing, Leveling Course by the number of square yards, complete and accepted in place. The City will base the width of the pavement course on the width shown on the plans, specified in this specification, or directed by the Engineer. The City will measure the length along the centerline of each roadway or ramp.

The City will measure the number of raised pavement markers removed.

The City will measure Microsurfacing, Rut Fill Course by the number of tons of dry aggregate used, complete and accepted in place. The City will base the weight of the dry aggregate used on the ticket net weight of individual loads from an approved scale.

421.14 Basis of Payment. The cost of Item 407 Tack Coat and Item 423 Crack Sealing shall be separate pay items to Microsurfacing.

The City will pay for removal of existing pavement markings according to 421.08 under Items 644, 645, 646, 647, and 648 as specified. The City will pay for removal of existing raised pavement markers according to Item 621 Raised Pavement Markers Removed.

The City will pay for the construction of accepted test strips at the individual bid prices for the courses constructed.

The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
421	Square Yard	Microsurfacing, Surface Course
421	Square Yard	Microsurfacing, Leveling Course
421	Ton	Microsurfacing, Rut Fill Course

ITEM 423 CRACK SEALING, HOT APPLIED

423.01 Description
423.02 Materials
423.03 Equipment
423.04 Weather Limitations
423.05 Preparation
423.06 Mixing Type II and III
423.07 Application of Sealant
423.08 Opening to Traffic
423.09 Method of Measurement
423.10 Basis of Payment

423.01 Description. This work consists of preparing and sealing pavement cracks with a hot applied crack sealant.

423.02 Materials. Furnish hot applied crack sealant, of the type specified, conforming to:

Type I 705.04
Type II 702.17.B
Type III 702.17.C
Type IV 702.17.D

Obtain the Laboratory's approval of Type I crack sealant before shipping to the project. Obtain approval of other crack sealants according to 702.17.

423.03 Equipment. Equipment used in the performance of this work is subject to the Engineer's approval and to the requirements of 108.05.

For Type I crack sealant, heat the sealant in a kettle or melter constructed as a double boiler, with the space between the inner and outer shells filled with oil or other heat-transfer fluid. Use a kettle or melter with positive temperature control of the oil bath, and provide a mixing vat, mechanical agitation, and recirculating pumps. Do not apply direct heat to the sealant.

For Types II, III, and IV crack sealants, heat the sealant in a kettle or melter constructed as a double boiler, with the space between the inner and outer shells filled with oil or other heat-transfer fluid. Use a kettle or melter with separate thermometers for the oil bath and mixing vat. Equip the

kettle with a full sweep type agitator. Also, equip the kettle with a 2-inch minimum recirculating pump to provide circulation of the materials when not applying the crack sealant. Do not apply direct heat to the sealant.

For Types I and IV crack sealants, use a mechanical applicator wand capable of continuously feeding the sealant through nozzles shaped to penetrate the cracks. A positive sealant flow shutoff mechanism is required. Ensure that the wand produces a band according to the tolerances of 423.07.

For Types II and III crack sealants, use a mechanical applicator wand head capable of placing the crack sealant according to the tolerances of 423.07 while filling the cracks. A positive sealant flow shutoff mechanism is required.

Use portable air compressors capable of furnishing at least 100 pounds per square inch of air pressure at the nozzle. Use compressors equipped with traps that maintain the compressed air free of oil and water.

Use water cleaning equipment capable of delivering water at 2000 pounds per square inch of pressure from a nozzle to the crack being cleaned.

Use a propane lance unit capable of producing a blast of hot air that operates at 1000 °F and a gas velocity of 2000 feet per second.

Use mechanical and power driven routing and sawing equipment capable of following close to the path of cracks and of widening the cracks to the required dimension without causing excessive spalling or damage to the adjacent pavement. For sawing equipment, use diamond saw blades with a diameter of 8 inches or less.

423.04 Weather Limitations. Do not seal cracks if the surface is visibly damp or the temperature is below 45 °F.

423.05 Preparation. Fill all cracks according to 423.07 or as directed by the Engineer.

If routing is specified, rout cracks with an opening less than 3/4 inch to provide a sealant reservoir with a nominal size of 3/4 inch wide by 1 inch deep.

If sawing is specified, saw all cracks to 3/4 to 7/8 inch wide and 7/8 to 1 inch deep. Use hand tools or a lightweight chipping hammer to remove all slivers of asphalt concrete less than 1 inch wide remaining along the crack after sawing. Immediately before sealing, sandblast both faces of the sawed crack to remove all contamination and to texture the faces. If the crack below the sealant reservoir is greater than 3/8 inch wide, insert a backer rod into the crack to form the bottom of the reservoir at the proper depth.

Before applying the hot sealant, clean cracks by an approved method or methods to remove dust, dirt, moisture, vegetation, and other foreign material. Keep the cracks clean and dry until all sealing operations are completed.

423.06 Mixing Type II and III. Use weigh tickets in determining the specified proportion of fiber to blend into the binder. Add fibers to the binder, and mix thoroughly in the kettle. Do not allow the temperature of the sealant in the field application to exceed the safe heating temperature recommended by the manufacturer. Do not heat Type III crack sealant to greater than 295 °F.

423.07 Application of Sealant. Perform the crack sealing operation within 250 feet of the cleaning operation.

Seal only cracks that are wide enough to permit entry of sealant. Seal tightly closed cracks (less than 1/4-inch wide) only if they show signs of raveling or spalling. Do not seal cracks greater than 1-inch wide, and do not seal spalls or cavities greater than 4 inches wide, unless otherwise directed.

For Types I and IV crack sealants, fill the entire crack reservoir with the sealant from the bottom up to approximately 1/16 inch above the pavement surface. Immediately scrape the filled cracks with a V-shaped or U-shaped squeegee, or similar hand tool, to smooth the overfill. This may require more than one application of sealant. The Engineer will not accept the work if the band of sealant on the pavement surface is greater than 2 inches wide.

For Types II and III crack sealants, place the sealant such that it fills the cracks with a band of sealant within 2 to 4 inches wide. The Engineer will not accept the work if the thickness on the pavement is greater than 3/16 inches.

423.08 Opening to Traffic. Do not allow traffic on the sealant until it has cured and the possibility of tracking no longer exists. However, if the Engineer determines it is necessary to allow traffic to pass over the sealant before adequate curing, dust portland cement or other approved material over sealed cracks to eliminate pickup or tracking.

423.09 Method of Measurement. The City will measure Crack Sealing, of the type specified, either by the number of pounds, the number of square yards, or the number of linear feet, of hot applied sealant in place, completed, and accepted.

423.10 Basis of Payment. The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
423	Pound, Square Yard, or Linear Foot	Crack Sealing, Type I
423	Pound, Square Yard, or Linear Foot	Crack Sealing with Routing, Type I
423	Pound, Square Yard, or Linear Foot	Crack Sealing with Sawing, Type I

423	Pound, Square Yard, or Linear Foot	Crack Sealing, Type II
423	Pound, Square Yard, or Linear Foot	Crack Sealing, Type III
423	Pound, Square Yard, or Linear Foot	Crack Sealing, Type II or III
423	Pound, Square Yard, or Linear Foot	Crack Sealing, Type IV

ITEM 424 FINE GRADED POLYMER ASPHALT CONCRETE

424.01 Description
424.02 Composition
424.03 Materials
424.04 Mixing
424.05 Weather Limitations
424.06 Spreading, Compacting and Finishing
424.07 Surface Tolerances
424.08 Acceptance
424.09 Method of Measurement
424.10 Basis of Payment

424.01 Description. This work consists of constructing a surface course of aggregate and polymer modified asphalt binder mixed in a central plant and spread and compacted on a prepared surface. The requirements of Item 401 apply, except as modified by this specification.

424.02 Composition. For Type A mixes use 8.5 percent modified asphalt binder by total mix weight.

For Type B mixes, submit a proposed JMF according to 441.02 to the Laboratory that meets the requirements of a Type 1 surface course, except as follows:

A. Minimum VMA, 15.0 percent

B. Minimum total binder content, 6.4 percent

C. Design air voids, 4.0 percent

D. For projects with less than 1500 trucks use 50 blows, for projects with greater than or equal to 1500 trucks use 75 blows. If multiple traffic segments occur on a project use 75 blows for the project.

424.03 Materials. Furnish clean, uncoated aggregate conforming to the applicable requirements of Table 424.03-1 and quality requirements of 703.05.

Use a PG 76-22M asphalt binder; or a PG 64-22 asphalt binder modified by adding 5.0 ±0.3 percent by weight Styrene Butadiene Rubber (SBR) solids and meeting the requirements of PG 76-22. Provide SBR conforming to 702.14. Provide mineral filler conforming to 703.07. Provide binders conforming to 702.01.

Ten percent RAP may be used in a Type B mix if all requirements of footnote [3] are met by the RAP. Do not use RAP in a Type A mix.

TABLE 424.03-1 - MIX GRADATION

Sieve Size	Total Percent Passing	
	Type A [1][2]	Type B [1][3][4]

1/2 inch		100
3/8 inch	100	95 to 100
No. 4	95 to 100	85 to 95
No. 8	90 to 100	53 to 63
No. 16	80 to 100	37 to 47
No. 30	60 to 90	25 to 35
No. 50	30 to 65	9 to 19
No. 100	10 to 30	--
No. 200	3 to 10	3 to 8

[1] Gradation includes any mineral filler and is specified in percent passing.
[2] Use natural sand with at least 50 percent silicon dioxide by weight according to ASTM C 146. Include with a JMF submittal certified test data from an AASHTO accredited laboratory showing conformance to the 50 percent silicon dioxide requirement. Ensure data is no more than one year old at time of submittal.
[3] Fine Aggregate - Use natural sand with at least 50 percent silicon dioxide by weight according to ASTM C 146. Include with a JMF submittal certified test data from an AASHTO accredited laboratory showing conformance to the 50 percent silicon dioxide requirement. Ensure data is no more than one year old at time of submittal. For 50 blow mixes, use no more than 20 percent limestone sand, No. 10 limestone, or combination of both by weight of total aggregate. For 75 blow mixes, use 20 percent limestone sand, No. 10 limestone, air cooled slag sand or combination thereof by weight of total aggregate. If 10 percent RAP is used the silicon dioxide content of the total natural sand blend must be at least 50 percent. Contact the Laboratory for guidance on submitting RAP aggregate silicon dioxide data.
[4] Coarse Aggregate - For 50 blow mixes, for the final blend of all coarse aggregate use a minimum 10 percent two or more fractured faces aggregate. For 75 blow mixes, use 100 percent two or more fractured faces aggregate. Meet the two or more fractured faces aggregate criteria of ASTM D5821-13.

424.04 Mixing. Ensure the mixing plant conforms to Item 402. Discharge the mix from the plant at temperatures from 335 °F to 370 °F for hot mix asphalt or 300 °F to 340 °F for warm mix asphalt.

424.05 Weather Limitations. Do not place the asphalt concrete when the surface of the existing pavement is less than 60 °F or the air temperature is less than 60 °F.

424.06 Spreading, Compacting and Finishing. Compact Type A or B mixes conforming to 401.13 and 401.16. If compacting a mixture 1 inch thick or less, do not use a spreading rate that exceeds twice the total capacity of the rollers in use. Use a minimum of two rollers. Do not allow traffic on the compacted mixture until it has cooled sufficiently to prevent damage.

424.07 Surface Tolerances. Ensure the completed surface course conforms to 401.19.

Remove raised pavement markers according to 621.08. The Contractor may fill the depression caused by the removal of the casting with material meeting this specification.

424.08 Acceptance. For Type A mixes, comply with acceptance requirements of Item 301. For Type B mixes, comply with all requirements of Item 448.

424.09 Method of Measurement. For Type A mixes, use a unit weight conversion of 1.75 tons/cubic yard.

The City will measure the number of raised pavement markers removed.

424.10 Basis of Payment. The City will pay for removal of existing raised pavement markers according to Item 621 Raised Pavement Markers Removed.

The City will make payment for accepted quantities, completed in place, at the contract price as follows:

Item	Unit	Description
424	Cubic Yard	Fine Graded Polymer Asphalt Concrete, Type A
424	Cubic Yard	Fine Graded Polymer Asphalt Concrete, Type B

ITEM 441 ASPHALT CONCRETE - MIX DESIGN AND QUALITY CONTROL

441.01 Description
441.02 Composition
441.03 Use of Reclaimed Pavement
441.04 Antistrip Additive
441.05 JMF Field Adjustment
441.06 Monitoring
441.07 Quality Control Program
441.08 Testing Facilities
441.09 Quality Control Tests
441.10 Control Charts
441.11 Quality Control Reports
441.12 Mixture Deficiencies
441.13 Acceptance

441.14 Basis of Payment

441.01 Description. This work consists of constructing a surface course or an intermediate course of aggregate and asphalt binder mixed in a central plant and compacted on a prepared surface. This specification includes general requirements applicable to all types of asphalt concrete pavements where the Contractor is responsible for performing the mix design and quality control. Deviations from these general requirements will be covered in the specific requirements for each type. The requirements of Item 401 apply, except as follows.

Control all production processes to assure the Engineer that the mixture delivered to the paving site is uniform in composition, conforms to the specification requirements and that the placed mixture is free of any defect (e.g. segregation, tenderness, lack of mixture and texture uniformity, raveling, flushing, rutting, holes, debris etc.) within the Contractor's control at project completion.

441.02 Composition. Compose the asphalt concrete of approved aggregates, asphalt binder and, if required, other modifiers. Develop a JMF to comply with the mix design criteria and submit it to the Laboratory on approved forms at least two weeks prior to the start of production for preliminary approval. The Laboratory may require additional time prior to preliminary approval to perform tests on lab or plant produced mixtures to ensure adequate mix performance. The Laboratory will notify the Contractor if additional time for testing is required. Based on the results of this testing, the Laboratory may require the Contractor to design a new JMF.

Perform the mix design and supply all required data in a manner taught in Level 2 Asphalt Technician School, Level 3 Asphalt Mix Design School and in the Asphalt Institute Manual Series No. 2. The Laboratory may visit the Level 3 mix design lab for review. Use a 2-hour cure for all mix samples. Ensure the cure temperature and specimen compaction temperature are the same. Select the JMF asphalt binder content using the Design Air Voids and ensure the JMF meets the other requirements of Table 441.02-1. Determine Air Voids from specimens prepared and tested according to City Supplement 1036. Provide a mix design with at least four asphalt binder content points, including a minimum of two points above and two points below the JMF asphalt binder content. Additional submittals are at the discretion of the Laboratory. Unless otherwise directed, submit a 5-pound minimum uncompacted sample (all mixes) representing the JMF. Submit additional samples as requested by the Laboratory.

Do not start mix production without a preliminary JMF approval and 48 hour notification of the Laboratory. Final approval of a JMF will be based upon field verification. According to 441.12, the JMF can be rejected for failure to verify in the plant or at the project.

Do not apply the gradation requirements of 703.05 for fine aggregate.

If the F/A ratio using total asphalt binder content is greater than 1.0, recalculate it using the effective asphalt binder content. Calculate the effective asphalt binder content according to the Asphalt Institute Manual Series No. 2The value (calculated to the nearest percentage point) of the Fifty to Thirty (F-T) value, is the percent of total aggregate retained between the No. 50 and No. 30 sieves, minus the percent of total aggregate retained between the No. 30 and No. 16 sieves.

Use a PG 64-22 asphalt binder for a Type 1 Intermediate course unless RAP used according to 401.04 require a virgin binder grade change. Use a PG 64-22 asphalt binder for a Type 2 intermediate course unless RAP used according to 401.04 require a virgin binder grade change. Use a PG 64-22 asphalt binder and Type 1 surface gradation for asphalt concrete for driveways and under guardrails.

Identify the PG Binder supplier, as well as the polymer type if applicable, on the JMF submittal. A change in polymer asphalt binder or polymer source will require a redesign. Provide on one page neatly summarized, dated test results for the requirements of Table 702.01-1. Ensure data is no more than two months old. If SBR polymer is added at the asphalt concrete mixing plant, provide in the JMF data from the SBR polymer supplier for total solids (percent) and ash (percent) according to the 702.14. As well, provide the target amount of SBR polymer greater than or equal to 3.5 percent to achieve the properties specified. Include a letter of certification from the polymer supplier verifying percent butadiene in the SBS or SBR polymer. Report in the JMF submittal results of temperature-viscosity testing for mixing and compaction temperatures. For polymer asphalt binders, supplier recommended temperatures may be used in lieu of the temperature-viscosity results, but the temperature-viscosity results must still be reported.

TABLE 441.02-1

Asphalt Mixture Composition			
Property	**Type 1 Surface**	**Type 1 Intermediate**	**Type 2 Intermediate**
1 1/2 inch [1]			100
1 inch [1]			95-100
3/4 inch [1]			85-100
1/2 inch [1]	100	100	65-85
3/8 inch [1]	90-100	90 to 100	
No. 4 [1]	45-57	50-72	35-60
No. 8 [1]	30-45	30 to 55	25-48
No. 16 [1]	17-35	17 to 40	16-36
No. 30 [1]	12-25	12 to 30	12-30
No. 50 [1]	5-18	5 to 20	5 to 18
No. 100 [1]	2-10	2 to 12	2 to 10
No. 200 [1]			
Asphalt Binder [2]	5.8-10.0	5.0 to 10.0	4.0 to 9.0
F/A Ratio, max .[3]	1.2	1.2	1.2
F-T Value [4]	+2	+2	
Blows [5]	50	50	50
Stability, min., pounds [5]	1200	1200	1200
Flow, 0.25 mm [5]	8 to 16	8 to 16	8 to 16
Design Air Voids [6]	3.5	3.5	4.0
VMA, min. [7]	16	16	13

[1] Sieve, percent passing
[2] Percent of total mix
[3] Using effective asphalt binder content
[4] Percentage points maximum
[5] T 245
[6] Percent, City Supplement 1036
[7] Percent, City Supplement 1037

441.03 Use of Reclaimed Pavement. Comply with the requirements of 401.04.

441.04 Antistrip Additive. If the proposed JMF contains any gravel coarse aggregate, or contains more than 25 percent natural sand, or contains more than 20 percent reclaimed asphalt concrete pavement containing gravel coarse aggregate, or is designed according to Item 442 conduct the following tests:

A. Moisture damage potential test according to City Supplement 1051.

B. Washed gradation according to AASHTO T 11 as modified by City Supplement 1004.

C. Adherent fines test for each component according to ASTM D 5711.

Modify the mix with one of the following antistrip additives if the results of the moisture damage potential test show the Tensile Strength Ratio (TSR) of the asphalt concrete mix to be less than 0.80 for 442 mixes or 0.70 for all other mix types:

Liquid Antistrip Material. Include liquid antistrip material at a rate of 0.5 to 1.0 percent by weight of the asphalt binder. However, if 442 is specified, include liquid antistrip material at a rate of 0.50 to 1.25 percent by weight of the asphalt binder. Ensure the TSR of the asphalt concrete mix is greater than or equal to 0.80 after the addition of the liquid antistrip material.

Hydrated Lime. Include hydrated lime in the dry form at a rate of 1.0 percent by the dry weight of aggregate for asphalt concrete. Conform to AASHTO M 303, Type 1 for hydrated lime. Ensure the TSR of the asphalt concrete mix is greater than or equal to 0.80 after the addition of the hydrated lime. Provide the Engineer the following information for each shipment of hydrated lime: Letter of certification, Production date, Shipment date, Shipment destination, Batch or lot number and Net weight. The Laboratory may obtain samples of the hydrated lime at any time to verify quality. If the quality of the hydrated lime is in question, the Laboratory may require independent laboratory testing.

Include the antistrip additive in the mix design. Submit the following to the Laboratory with the proposed JMF:

A. All TSR data (before and after the addition of the antistrip additive).

B. Rate of addition of the liquid antistrip material, if used.

C. If using liquid antistrip material submit product information, information on use by other State DOTs using the liquid antistrip material, and a letter of certification. If using hydrated lime submit certified test data showing the hydrated lime conforms to AASHTO M 303, Type 1.

D. Results of the washed gradation test of the individual components of the mix used in determining the combined gradation.

E. Results of the adherent fines testing for each component.

The Laboratory may perform additional tests on lab or plant produced mix according to City Supplements 1004 and 1051. If a change in the aggregate production is suspected, the City may require the Contractor to perform washed gradations on components and calculate adherent fines to determine the need for additional TSR review. Store and introduce antistrip additives into the plant according to City Supplement 1053. Obtain Laboratory approval of the antistrip additive storage and feed systems prior to the start of production.

Provide delivery tickets to the Engineer at the end of the project and at the end of each construction year on a multiple year project. The Engineer will verify the number of pounds of antistrip additive used is within 10 percent of the calculated amount of antistrip additive required for the total weight of asphalt binder, based on the JMF, used in the asphalt concrete.

441.05 JMF Field Adjustments. During the first three days of production, the Contractor may adjust the JMF gradation within the below limits without a redesign of the mixture. For projects with less than 3 days of production, give the Laboratory written notice of any JMF gradation adjustments within 1 workday following the last day of production. Limit adjustments of the JMF to conform to actual production, without a redesign of the mixture, to ±3 percent passing each of the 1/2 inch, No. 4, and No. 8 sieves and ±1 percent passing the No. 200 sieve. Do not exceed the limits in Table 441.02-1 and Table 442.02-2 in the adjusted JMF. The adjustment on the 1/2 inch sieve applies only to the Type 2 mixes. Determine the need for any JMF gradation adjustments in the time specified. Should no adjustments be made, the City will base acceptance on conformance to the original JMF. After the time period specified, the City will allow no further adjustment of the JMF.

Should a redesign of the mixture become necessary, submit a new JMF according to the requirements for the initial JMF. Acceptance quantities will be based on each JMF production shift. Make any adjustment of this new JMF as provided for the original JMF. Record both the design JMF and the adjusted JMF in effect during production on the Quality Control Report. In the event that a new JMF is proposed and approved, also make a notation on the ticket for the first load produced under the new JMF.

441.06 Monitoring. The City will establish a Monitoring Team for the purpose of verifying all Contractor mixture production processes. Verification may be accomplished by obtaining split samples from Contractor QC or independent samples from the plant or roadway. If independent samples are taken split them for Contractor testing. If the mixture quality verifies then production may continue. If mixture quality does not verify then the Monitoring Team and Contractor will cooperatively investigate and resolve the problem. Whenever results are disputed, the City will investigate and conduct additional testing to resolve. Based on the Monitoring Team's review, the Engineer may at any time disallow production to continue.

441.07 Quality Control Program. Submit a Quality Control Program (QCP) according to 403.03. Include an example control chart per 441.10 with the QCP. Use quality control technicians working in the plant lab during all mixture production and that are approved by the City. Technician approval will be according to City Supplement 1041.

441.08 Testing Facilities. Provide testing facilities at the plant site conforming to City Supplement 1041.

441.09 Quality Control Tests. Perform quality control tests to control the asphalt concrete mix within the specifications. As required by mix type, ensure that these quality control tests measure the asphalt binder content, gradation, air voids, and Maximum Specific Gravity (MSG) according to the Contractor's approved QCP. Perform quality control testing according to the following schedule of testing based on material loaded for delivery during each shift:

0 to 100 tons	No testing required
101 to 200 tons	One "Basic" test per Item 403.05
201 to 500 tons	Complete set of QC tests per this section
501 to 1000 tons	Complete set of QC tests per this section
1001 to 1500 tons	Complete set of QC tests per this section

All QC testing requirements will be based on delivery ticket load times for material delivered to City of Columbus projects during a shift. No QC testing is required for shift quantities of less than 100 tons unless visual observations indicate a potential issue may exist with the mix. A shift is defined as one twelve-hour period starting at either 6:00 am or 6:00 pm. The basic test and first complete set of tests may be combined to account for the first 500 tons produced and loaded for the shift.

Perform more sampling and testing than the minimum specified at the start of production. Additionally perform more sampling and testing than the minimum during production when the quality control tests show the asphalt concrete being produced is outside the warning bands as shown in the Contractor's approved QCP. Immediately resolve problems indicated by any test result exceeding the warning bands and immediately retest to validate corrections have returned the materials to within the warning band limits. The Contractor may determine the method of testing of the asphalt concrete beyond the minimum specified, and will detail the methods technicians will follow in the Contractor's approved QCP.

Should additional testing as required above not be performed, the Engineer, after consultation with the Laboratory, will require the testing frequency be increased to all tests every two hours of production for the remainder of the project. If this occurs, the Engineer will request an opinion from the City Engineer for action(s) against the technician and/or Contractor including but not limited to warning, removal and/or a change of the facility to Unconditional Acceptance.

Record the results of every test performed.

Perform the required quality control tests as follows:

A. Asphalt Binder Content. Determine the asphalt binder content of a sample of asphalt concrete by performing an Asphalt Content (AC) Gauge test according to City Supplement 1043. Make all printouts available for review by the Laboratory at any time. Offset the AC Gauge for each JMF on each project at the project's start. Perform the offset using the solvent extraction method for every QC sample according to City Supplement 1038 and the AC Gauge Verification and Offset Record until the offset is established. Use solvent extraction according to City Supplement 1038 when an AC Gauge problem exists and for testing cooled samples that cannot adequately be tested in an AC Gauge test.

Total, for each day's production, the flow meter printouts for SBR polymer added at the asphalt concrete mixing plant. Calculate the percent of polymer versus neat asphalt binder in the mix each day and record on the TE-199. Hold calculation worksheets and printouts in the plant laboratory for review by the Laboratory. A +/- 0.2 percent tolerance from the target amount of SBR polymer will be used as a guide for an acceptable amount of SBR polymer, but consistently low will not be acceptable. Only take SBR PG-Modified Binder samples using a five gallon bucket. Take 1 gallon to clean the valve port and discard. Take 2 gallons again, stir its contents and transfer to the required sample containers.

Determine the moisture content of the asphalt concrete for each AC Gauge test. Maintain the moisture content at 0.8 percent or less.

B. Gradation. Perform at least one gradation test each production day on aggregate remaining after removing the asphalt binder with a solvent from an asphalt concrete sample used in an AC Gauge test (solvent sample) or on aggregate remaining after removing the asphalt binder with a preapproved asphalt ignition oven according to City Supplement 1054 and from an asphalt concrete sample used in an AC Gauge test (ignition oven sample). Use only an asphalt ignition oven to obtain an aggregate sample from an asphalt concrete sample having a polymer modified PG Binder. The Engineer may make an exception to this for SBS polymer as long as no issues arise. Correct each solvent sample for ash. Perform all other gradations on solvent samples, ignition oven samples, or on samples obtained according to the Contractor's approved QCP.

The gradation results of all the sieves must be representative of the JMF. If the Contractor fails to control the entire gradation, the Laboratory may require a redesign according to 441.02.

When the F-T value is specified for a mix in 441.02 calculate it for each gradation analysis. Maintain the F-T value at +4 percentage points or less for these mixes.

Calculate the F/A ratio for every solvent sample or ignition oven sample analysis. Maintain the F/A ratio so no F/A ratio is greater than 1.2 for all mixes. Use the asphalt binder content determined by the AC Gauge for calculating the F/A ratio. If the F/A ratio is greater than 1.0, recalculate the F/A ratio using the effective asphalt binder content. Calculate the effective asphalt binder content on the calculation sheet using the asphalt binder content determined by the AC Gauge and attach it to the Quality Control Report. Use bulk and effective aggregate specific gravities and remaining values needed in the calculation from the approved JMF. Do not deviate from these values without the Laboratory's approval. If the F/A ratio is greater than 1.0 for ignition oven samples, calculate the F/A ratio using the percent passing the No. 200 sieve from a washed gradation of the ignition oven sample according to AASHTO T 30.

C. Air Voids and MSG. Determine the air voids of the asphalt concrete by analyzing a set of compacted specimens and a corresponding MSG determination according to City Supplement 1036. Ensure that the cure temperature and specimen compaction temperature are the same. Use a 1-hour cure for all mix samples used in voids analysis. The Contractor may use a 2-hour cure time if voids are consistently near the low void warning band. In this case, use the 2-hour cure for all voids testing through the remainder of the project. For hot mix asphalt use the JMF lab compaction temperature. For warm mix asphalt according to 402.04 use a lab compaction temperature 30.0 ºF less than the JMF lab compaction temperature for hot mix asphalt. Use a compaction temperature tolerance of +/- 5.0 ºF. Record on the TE-199 if the mixture produced was ran at the asphalt plant as a hot mix asphalt (HMA) or as a warm mix asphalt (WMA) produced according to 402.04 or another approved method.

Calculate the Voids in Mineral Aggregate (VMA) value for every set of compacted specimens according to City Supplement 1037.

Calculate the average of all the MSG determinations performed each production day and report this average on the Quality Control Report. When the range of three consecutive daily average MSG determinations is equal to or less than 0.020 average these three average MSG determinations to determine the Maximum Theoretical Density (MTD). After the MTD is established, compare all individual MSG determinations to the MTD.

Whenever compacted specimens are to be made and an MSG determination is to be run, take a sample of sufficient size to run a corresponding AC Gauge test. When the air void and MSG test results are recorded reference them to the AC Gauge test of the sample.

D. Other Requirements. Supply proper containers and take two 1 quart asphalt binder samples from the first transport truck load of each different asphalt binder grade of the project before incorporation into the storage tank. Label the samples with binder grade, supplier, project number and date and retain them in the plant laboratory for future reference by the City. Discard the samples at the Project's Final Acceptance if not taken by the Laboratory.

Retain a split sample for each AC Gauge test and MSG test and all compacted specimens for monitoring by the City. Maintain MSG samples in the state described in ASTM D 2041, Section 9.2. The Contractor may dispose of the AC Gauge test samples after two days and all other split samples after seven days if the City does not process the split samples.

Measure the temperature of the mixture and record. Validate the results on the load tickets at least once during each hour of production.

The Contractor may conduct additional testing of any type. Record such additional testing along with all other quality control records and have these records readily available for the Laboratory's review. The Laboratory may observe, review, and approve the procedures at any time.

441.10 Control Charts. Maintain up to date control charts showing each individual test result and also the moving accumulative range as follows:

A. Plot tests showing the percent passing for the 1/2 inch, No. 4, No. 8, and No. 200 sieves the percent asphalt binder content, the MSG and the percent air voids. Round all percentages to the nearest whole percent; except, round asphalt binder content, the No. 200 sieve, and air voids to the nearest 0.1 percent.

B. Show the out of specification limits specified in Table 441.10-1 and QCP Warning Band Limits on the control charts.

C. Label each control chart to identify the project, mix type and producer.

D. Record the moving accumulative range for three tests under each test point on the chart for air voids and asphalt binder content. Accumulative range is defined as the positive total of the individual ranges of two consecutive tests in three consecutive tests regardless of the up or down direction tests take. If more than the minimum required testing (i.e. two tests per production day or night, 441.09 first paragraph) is performed do not include the result in accumulative range calculations.

Stop production and immediately notify the Laboratory when either E or F occurs:

E. Any two tests in a row or any two tests in two days are outside of the specification limits of Table 441.10-1.

F. Any four consecutive moving accumulative ranges greater than specification limits of 2.50 percent for air voids or 0.60 percent for asphalt binder content occur.

Any mixture sent to the paving site without stopping production and notifying the Laboratory when required by this specification will be considered non-specification material.

Do not restart production until an adequate correction to remedy problems is in place and the Laboratory is satisfied. Following a shutdown restart production in a manner acceptable to the Engineer. When production problems cannot be solved within one day after a plant shut down, a Contractor's representative holding Level 3 Asphalt City approval is required to be at the asphalt plant until a full production day is achieved with results satisfactory to the Laboratory.

TABLE 441.10-1

Mix Characteristic	Out of Specification Limits [5]
Asphalt Binder Content [1]	-0.3% to 0.3%
1/2 inch sieve [1]	-6.0% to 6.0%
No. 4 sieve [1]	-5.0% to 5.0%
No. 8 sieve [1]	-4.0% to 4.0%
No. 200 sieve [1]	-2.0% to 2.0%
Air Voids [2]	2.5% to 4.5%
Air Voids [3]	3.0% to 5.0%
MSG [4]	-0.012 to 0.012

[1] deviation from the JMF
[2] for Design Air Voids of 3.5%
[3] for Design Air Voids of 4.0%
[4] deviation from the MTD
[5] unless otherwise restricted by mix type specification

441.11 Quality Control Reports. Use Form TE-199 for the Quality Control Report. Record all test results on the Quality Control Report. Document all decisions regarding responses to test results on the Quality Control Report (referring to the particular test), including reasons why a particular problem may exist what action was taken to correct the problem (plant operation or testing), and what communication with City personnel took place. Submit one Quality Control Report to the Engineer no later than specified. Retain copies of all records documenting the quality control inspections and tests throughout the life of the Contract and furnish them to the Engineer on request.

441.12 Mixture Deficiencies. Control all production processes to assure the Engineer that the mixture delivered to the paving site is uniform in composition; within the specification requirements and limits; conforms to the JMF; and that the placed mixture is free of any defect (ex. segregation, tenderness, lack of mixture and/or texture uniformity, raveling, flushing, rutting, holes, debris etc.) within the Contractor's control. Correct obvious pavement problems according to 401.15. If the City has any suspicion that other mixture composition or pavement problems exist, the Laboratory will conduct an initial investigation through review of data and sampling of the asphalt pavement. Should a City investigation determine that the Contractor's QCP is not controlling the mixture in a manner to achieve mixture quality as described above the Contractor quality control data may be rejected. In that case the City will conduct a thorough investigation by testing samples from the roadway and use those test results in determining disposition of the non-specification material.

A mixture is not uniform in composition if multiple random non-specification individual tests or any four consecutive non-specification moving accumulative ranges exist. The mixture can be rejected, production can be stopped and/or a redesign can be called for by the City. The Laboratory will not approve any redesign it determines is unsatisfactory to provide acceptable mix performance. Submit this new design for approval according to 441.02 and at no additional cost to the City.

When any out of specification material, based on quality control tests not within the limits of Table 441.10-1, is sent to the paving site, the Engineer will determine disposition of the material according to City Supplement 1102.

441.13 Acceptance. The City will base acceptance of the asphalt concrete mix on the item specified in the Contract item description. (i.e. Item 446, 448).

441.14 Basis of Payment. The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
441	Cubic Yard	Asphalt Concrete Surface Course, Type 1, (448), PG64-22
441	Cubic Yard	Asphalt Concrete Surface Course, Type 1, (446), PG64-22
441	Cubic Yard	Asphalt Concrete Surface Course, Type 1, (448), PG70-22M
441	Cubic Yard	Asphalt Concrete Surface Course, Type 1, (446), PG70-22M
441	Cubic Yard	Asphalt Concrete Intermediate Course, Type 1, (448)
441	Cubic Yard	Asphalt Concrete Intermediate Course, Type 2, (448)
441	Cubic Yard	Asphalt Concrete Intermediate Course, Type 2, (446)

ITEM 442 SUPERPAVE ASPHALT CONCRETE

442.01 Description
442.02 Type A Mix Design
442.03 Type B Mix Design
442.04 Asphalt Binder
442.05 Quality Control
442.06 Compaction
442.07 Acceptance
442.08 Basis of Payment

442.01 Description. This work consists of gyratory mix design, material, and quality control requirements for constructing a Superpave asphalt concrete pavement surface or intermediate course. The asphalt concrete pavement course consists of aggregate, and asphalt binder mixed in a central plant and spread and compacted on a prepared surface.

The requirements of Item 441 apply, except as modified by this specification.

442.02 Type A Mix Design. Design the mixture composition for a Type A mix according to 441.02 and the most recent Asphalt Institute Manual Series No. 2 (MS-2) for design procedures and material properties except as modified by this subsection. Include in the JMF submittal the standard City cover and summary page; all printouts from the gyratory compactor (all gyratory points not necessary); and analysis covering the required mix properties.

The Contractor may use the Marshall flow test in design as an indicator of potential for excess tenderness.

Supply aggregate according to the lane current average daily truck traffic (Lane ADTT) as follows unless otherwise shown on the plans:

$$\text{Lane ADTT} = \text{Current ADT} \times T_{24} \times 0.45$$

Where:

Current ADT = current average daily traffic count from the plans

T_{24} = percent trucks per day from the plans

TABLE 442.02-1 GYRATION LEVEL AND MATERIAL REQUIREMENTS

Lane ADTT	Nini	Ndes	Nmax	Coarse Aggregate Angularity	Fine Aggregate Angularity	Flat and Elongated Particles	Sand Equivalent
<4000	7	65	105	95 [1] /90 [2]	44	10	45
>4000	7	65	105	100 [1] /100 [2]	44	10	50

[1] Percent fractured (one or more faces) according to ASTM D5821
[2] Percent fractured (two or more faces) according to ASTM D5821

If fine aggregate is from crushed carbonate stone or air-cooled blast furnace slag, the City will not require the fine aggregate angularity (FAA) test. The City will allow a blend of a material not meeting the FAA with a material that meets the FAA, but calculate the FAA result based on the individual City FAA results and actual blend percentages. Obtain City approval of any blends.

The restricted zone does not apply. Use control points according to MS-2, except as specified in Table 442.02-2.

TABLE 442.02-2 AGGREGATE GRADATION REQUIREMENTS

Sieve Size		9.5 mm mix	12.5 mm mix	19 mm mix
		Total Percent Passing		
1 1/2 inch	(3.75 mm)	–	–	100
3/4 inch	(19 mm)	–	100	85 to 100
1/2 inch	(12.5 mm)	100	95 to 100	90 max
3/8 inch	(9.5 mm)	90 to 100	96 max	–
No. 4	(4.75 mm)	70 max	52 to 60 [1]	–
No. 8	(2.36 mm)	34 to 52	34 to 45	28 to 45
No. 200	(75 µm)	2 to 8	2 to 8	2 to 6
[1] For the No. 4 sieve, do not exceed 63 in production.				

Ensure that the F/A ratio is a maximum of 1.2. Use a 2-hour cure for the mix design.

If more than 15 percent fine aggregate not meeting FAA is used, perform a loaded wheel test (LWT) according to City Supplement 1057. To estimate a LWT sample mix volume, use the bulk density from gyratory specimens at N_{des}. Results less than 0.20 inch (5.0 mm) at 120 °F (49 °C) are considered passing.

The Contractor may use reclaimed asphalt concrete pavement according to 401.04. Test design volumetric properties at N_{des}. Test N_{max} for the required criteria. Ensure that the VMA is not less than the minimum values of Table 442.02-3.

TABLE 442.02-3 VMA CRITERIA

Mix	VMA (percent minimum)
9.5 mm	15.0
12.5 mm	14.0
19.0 mm	13.0

442.03 Type B Mix Design. Apply the mix design specified in 442.02 for a Type A mix except as modified by this subsection:

Modify the Coarse Aggregate Angularity of Table 442.02-1 according to Table 442.03-1.

TABLE 442.03-1

Lane ADTT	Coarse Aggregate Angularity
<4000	65 [1] /65 [2]
>4000	75 [1] /70 [2]
[1] Percent fractured (one or more faces) according to ASTM D5821 [2] Percent fractured (two or more faces) according to ASTM D5821	

Ensure that at least 50 percent by weight of virgin fine aggregate is aggregate meeting FAA or is crushed carbonate stone or air-cooled blast furnace slag. Modify the No. 8 sieve requirement for a 12.5 mm mix in Table 442.02-2 to 34 to 40 percent. Apply an F-T value of +2 according to 441.02 and 441.09.

442.04 Asphalt Binder. Use a PG 70-22M asphalt binder for surface courses and a PG 64-28 asphalt binder for intermediate courses.

The minimum total asphalt binder content for a surface course is 5.7 percent.

442.05 Quality Control. Conform to 441.09, except as specified in this subsection. Ensure that plant operation and quality control testing conform to the Contractor's Quality Control Program (QCP).

For 12.5mm mixes, ensure the percent passing the No. 4 sieve does not exceed 63 in production. If two tests in a row or any two tests in two days (QC and/or 448 day's production) exceed 63, stop production and notify Laboratory.

Use a gyratory compactor conforming to the requirements of Superpave. If the gyratory compactor was moved to the plant before production, calibrate it and present the results to the Laboratory.

Determine bulk gravity for air voids determination on specimens compacted to N_{des}.

If the design gradation requires an LWT test, take a sample sufficient to run a LWT test once each day for the first 3 days and test it according to City Supplement 1057. The Contractor may perform the LWT test in the Contractor's Level 2 laboratory, but must compact the sample the same day the sample was taken, cure it overnight, and test it the following day. Give the test result and sample density to the Engineer the day of the LWT test. Report the LWT data on the Quality Control Report.

442.06 Compaction. Cease production if compaction causes bumps in the mix or the mix is excessively tender.

442.07 Acceptance. The City will base acceptance of the asphalt concrete mix on the method specified in the Contract line item description (i.e. Item 446, 448).

442.08 Basis of Payment. The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
442	Cubic Yard	Asphalt Concrete Surface Course, 12.5 mm, Type A (446)
442	Cubic Yard	Asphalt Concrete Surface Course 12.5 mm, Type B (446)
442	Cubic Yard	Asphalt Concrete Surface Course, 9.5 mm, Type A (446)
442	Cubic Yard	Asphalt Concrete Surface Course, 9.5 mm, Type B (446)
442	Cubic Yard	Asphalt Concrete Intermediate Course, 19 mm, Type A (446)
442	Cubic Yard	Asphalt Concrete Intermediate Course, 19 mm, Type B (446)
442	Cubic Yard	Asphalt Concrete Intermediate Course, 9.5 mm, Type A (448)
442	Cubic Yard	Asphalt Concrete Intermediate Course, 9.5 mm, Type B (448)
442	Cubic Yard	Asphalt Concrete Surface Course, 12.5 mm, Type A (448)
442	Cubic Yard	Asphalt Concrete Surface Course, 12.5 mm, Type B (448)
442	Cubic Yard	Asphalt Concrete Surface Course, 9.5 mm, Type A (448)
442	Cubic Yard	Asphalt Concrete Surface Course, 9.5 mm, Type B (448)
442	Cubic Yard	Asphalt Concrete Intermediate Course, 19 mm, Type A (448)
442	Cubic Yard	Asphalt Concrete Intermediate Course, 19 mm, Type B (448)

ITEM 446 ASPHALT CONCRETE CORE DENSITY ACCEPTANCE

446.01 Description
446.02 Monitoring
446.03 Reports
446.04 Density Acceptance
446.05 Joints

446.01 Description. This specification describes the acceptance criteria for asphalt concrete surface and intermediate courses. The City will base acceptance of the compacted mixture in place on the level of density attained as sampled by the Contractor and analyzed by the City.

446.02 Monitoring. If there is poor comparison between the City's comparison samples and the Contractor's quality control tests, the Monitoring Team may at any time disallow acceptance to continue under Item 446. In this case, accept per Item 448 and Item 446. The City will notify the Contractor in writing to stop production.

446.03 Reports. Submit the Quality Control Report according to 441.11 on the workday following the production day of the material represented by the report.

446.04 Density Acceptance. The requirements of 401.13 do not apply. However, rollers must fully and satisfactorily provide the required compaction, be mechanically sound, and meet Asphalt industry standards. The City retains the right to reject the use of rollers which are not in good repair, or are not designed to do the work required. A three-wheel roller according to 401.17 is not required.

Obtain ten, 4-inch cores for the City to test to determine the in-place density of the compacted mixture as a percentage of the average QC Maximum Specific Gravity (MSG) for the production day the material was placed. If City MSG VA tests show poor comparison to the average QC MSG according to 403.06, use City determined MSG results in the density calculation for each production day. Compact shoulders using the same equipment and procedures as used on the mainline pavement. The requirements of 401.16, except for the last four paragraphs, are waived.

Payment for compaction of all asphalt placed is by daily production, based upon the degree to which density is attained. Payment for shoulders depends on the degree to which the density is obtained on the adjacent mainline pavement lane or ramp. However, when a cold longitudinal joint is made between a mainline pavement lane and an adjoining shoulder, payment for the shoulder will be based on the degree to which the density is obtained on the shoulder.

A day's production consists of an area of pavement placed during a production day, including the shoulders. If less than 300 tons is produced in a production day, then that production day is combined with the next production day into a day's production. If less than 300 tons is produced on the last production day for the project, it is part of the previous day's production for acceptance.

Within 48 hours after the pavement is placed or prior to opening to traffic, obtain ten cores for each day's production at random locations the Engineer determines. Only obtain core samples in the presence of the Engineer and immediately surrender each core sample to the Engineer for

testing. The Engineer will divide a day's production into ten equal sections and designate one random core location in each section. Both mainline pavement and ramps will be included in the day's production determinations. The Engineer will not give the Contractor random core locations early in the placement. Cores will be taken as follows. Three cores will be taken from cold longitudinal joints (joint cores) and seven cores will be taken from the mat (mat cores). Do not take joint cores from ramp joints. Take joint cores from the first, last and randomly from one of the remaining sections. Except where notched wedge joints are used, take joint cores such that the core's closest edge is 4 inches from the edge of the mat. Obtain the mat cores from at least twelve inches away from the longitudinal joint. Locate cores obtained for Contractor quality control (QC sister core) longitudinally from and within four inches of the random core. In addition to the QC sister cores, three/five extra cores may be taken from the first day's production of a JMF for testing to correlate density gauges. Do not take additional cores beyond what is noted above unless clearly identified in the Contractor's QCP. Clearly label all cores with mat locations so that they may be readily identified. Any unlabeled cores may be destroyed by the City. Notify the Laboratory if any questions arise. Do not store additional cores anywhere (project, in vehicles or at the plant) beyond those required to be taken for testing. Test all Contractor QC cores and maintain records of all tests (core tests and correlated gauge tests) per the QCP. Destroy all cores immediately after testing is complete.

Notched Wedge Joints: When notched wedge joint construction is used, do not take cores on the sloped face of the wedge before the adjoining lane (matching pass) is placed. Take cores such that the core's closest edge is six inches from the edge of the joint upper notch. When a nine inch or wider wedge joint is used, take the core three inches from the upper wedge joint notch.

The City will determine the pay factor for each day's production cored by the pay schedule in Table 446.04-1 for daily production with three cold longitudinal joint cores and Table 446.04-2 for daily production with less than three cold longitudinal joint cores. The City will verify the Maximum Theoretical Density (MTD) if the MSG determination has a deviation from the MTD of less than or equal to 0.020. If the MTD is not verified, establish a new MTD according to the procedures established in 441.09. If less than 10 cores are available for determining the mean, the City will determine disposition of the day's production.

Fill core holes by the next workday with hot-mix asphalt concrete. Before filling, ensure the holes are dry and tack them with asphalt material conforming to 407.02. Properly compact the asphalt concrete used for filling the hole and leave it flush with the pavement.

TABLE 446.04-1 FOR DAY'S PRODUCTION WITH 3 COLD JOINT CORES

Mean of Cores [1]	Pay Factor	
	Surface Course	**Intermediate Course**
98.0% or greater	[2]	[2]
97.0 to 97.9%	0.94	[2]
96.0 to 96.9%	1.00	0.94
93.4 to 95.9%	1.04 [4]	1.00
92.4 to 93.3%	1.00	1.00
91.4 to 92.3%	0.98	1.00
90.4 to 91.3%	0.90	0.94
89.4 to 90.3%	0.80	0.88
88.4 to 89.3%	[3]	[3]
Less than 88.4%	[2]	[2]

[1] Mean of cores as percent of average MSG for the production day.
[2] For surface courses, remove and replace. For other courses, the City will determine whether the material may remain in place. If the City determines the course should be removed and replaced, the Contractor will remove and replace this course and all courses paved on this course. The pay factor for material allowed to remain in place is 0.60.
[3] The City will determine whether the material may remain in place. If the City determines the course should be removed and replaced, the Contractor will remove and replace this course and all courses paved on this course. The pay factor for such material allowed to remain in place is 0.70.
[4] No incentive will be paid if any single cold joint core is less than 91.0%.

TABLE 446.04-2 FOR DAY'S PRODUCTION WITH LESS THAN 3 COLD JOINT CORES

Mean of Cores [1]	Pay Factor	
	Surface Course	Intermediate Course
98.0% or greater	[2]	[2]
97.0 to 97.9%	0.94	[2]
96.0 to 96.9%	1.00	0.94
94.0 to 95.9%	1.04 [4]	1.00
93.0 to 93.9%	1.00	1.00
92.0 to 92.9%	0.98	1.00
91.0 to 91.9%	0.90	0.94
90.0 to 90.9%	0.80	0.88
89.0 to 89.9%	[3]	[3]
Less than 89.0%	[2]	[2]

[1] Mean of cores as percent of average MSG for the production day.
[2] For surface courses, remove and replace. For other courses, the City will determine whether the material may remain in place. If the City determines the course should be removed and replaced, the Contractor will remove and replace this course and all courses paved on this course. The pay factor for material allowed to remain in place is 0.60.
[3] The City will determine whether the material may remain in place. If the City determines the course should be removed and replaced, the Contractor will remove and replace this course and all courses paved on this course. The pay factor for such material allowed to remain in place is 0.70.
[4] No incentive will be paid for a day's production where 3 joint cores are required to be taken but less than 3 cores are taken.

446.05 Joints. Construct joints according to 401.17. Make a hot longitudinal joint between the mainline pavement lane and the adjoining shoulder and all ramps and the adjoining shoulders. If a hot longitudinal joint is specified between the mainline pavement lanes, the Contractor may construct a cold longitudinal joint between the mainline pavement lanes and the adjoining shoulders. Cold longitudinal joints in mainline pavement will be tested according to 446.04.

ITEM 448 ASPHALT CONCRETE ACCEPTANCE

448.01 Description
448.02 Density
448.03 Reports
448.04 Acceptance

448.01 Description. This specification describes the acceptance criteria for asphalt concrete surface and intermediate courses. The City will determine acceptance of the mixture by daily production, based on the composition of random samples taken and tested by the Contractor and verified by the City.

448.02 Density. Conduct density gauge quality control testing on the asphalt mat according to City Supplement 1055. Conduct density gauge testing on uniform courses of 1.0 in or more plan thickness. Conduct density gauge testing on projects with a daily minimum of 200 tons of paving (excepting bridges, intersections, etc.). Do NOT enter a density gauge offset of any kind into the gauge. If an offset is already in the gauge remove it. Verify to the Engineer daily that no offset is present in the gauge. All values used in controlling mat density according to City Supplement 1055 will be as calculated and written on forms supplied in City Supplement 1055.

When City Supplement 1055 density gauge testing is required, the requirements of 401.16, except the last four paragraphs, are waived. The requirements of 401.13 do not apply. However, rollers must fully and satisfactorily provide the required compaction, be mechanically sound, and meet Asphalt industry standards. The City retains the right to reject the use of rollers which are not in good repair, or are not designed to do the work required. A three-wheel roller per 401.17 is not required.

448.03 Reports. Refer to Item 403 for reporting requirements of asphalt mixtures tested at the asphalt plant. Report density gauge QC testing results according to City Supplement 1055.

448.04 Acceptance. Refer to Item 403 for acceptance requirements. If a project includes 448.02 Density, acceptance will include any density deductions according to City Supplement 1055.

450 RIGID PAVEMENT

ITEM 451 REINFORCED PORTLAND CEMENT CONCRETE PAVEMENT

451.01 Description
451.02 Materials
451.03 Not Used
451.04 Equipment
451.05 Setting Forms
451.06 Fine Grading of Subgrade or Subbase
451.07 Placing Concrete
451.071 Depositing and Curing Concrete during Cold Weather
451.08 Placing Reinforcement
451.09 Joints
451.10 Finishing
451.11 Curing
451.12 Removing Forms
451.13 Surface Smoothness
451.14 Profile Grinding
451.15 Pavement Grooving Corrections
451.16 Sealing Expansion Joints
451.17 Opening to Traffic
451.18 Pavement Thickness and Concrete Strength
451.19 Price Adjustments
451.20 Method of Measurement
451.21 Basis of Payment

451.01 Description. This work consists of constructing a pavement composed of reinforced portland cement concrete on a prepared surface.

451.02 Materials. Furnish materials conforming to:

Concrete,
either Class COC 1, or COC MS 499
Joint sealer.....705.04
Preformed filler 705.03
Curing materials .....705.05, 705.06, 705.07 Type 2
Tiebar steel, epoxy coated 709.00
Reinforcing steel 709.09, 709.10, 709.12
Dowel bars and basket assemblies 709.13

451.03 Not Used.

451.04 Equipment. Furnish self-propelled spreading and finishing machines capable of consolidating and finishing the concrete and producing a finished surface meeting the requirements specified. Ensure that all paving equipment is operated in a manner that does not result in segregation of the mixture or loss of air entrainment in the mixture.

Construct pavement using either fixed forms or slip form paving equipment that conforms to the following:

A. Fixed Form Construction. Spread, screed, and consolidate concrete using one or more machines between previously set side forms. Furnish an adequate number and capacity of machines to perform the work at a rate equal to the concrete delivery rate. Furnish machines capable of uniformly distributing and consolidating the concrete without segregation.

Provide machines capable of operating on two side forms, on adjacent lanes of pavement and one side form, or on two adjacent lanes as necessary. When placing concrete adjacent to an existing pavement lane, take measures to protect the adjacent pavement from damage. Remove from the work any machine that causes displacement of the side forms from the line or grade or causes undue delay, as determined by the Engineer, due to mechanical difficulties.

Finish small areas, irregular areas, and areas that are inaccessible to finishing equipment using other methods as approved by the Engineer. Accomplish vibration of these areas using hand held or machine mounted internal vibrators. Continue vibration to achieve adequate consolidation, without segregation, for the full depth and width of the area placed.

Use straight edge side forms made of steel and of a depth equal to the specified pavement thickness. Do not use bent or damaged side forms or forms with damaged joint locks or pin pockets. Clean and oil all forms each time they are used. Provide forms in sections of not less than 10 ft in length without horizontal joints in the height of the form. Utilize forms with a nominal base width of at least 3 inches. Ensure forms are capable of supporting the paving equipment without shifting or deforming during paving. If the radius of the circular pavement edge is 100 feet or less, use flexible or curved forms of a design acceptable to the Engineer. Provide adequate devices to securely set forms and withstand operation of the paving equipment. Do not use built-up forms except to construct pavement of a specified thickness whose total area for the project is less than 2000 square yards. Provide forms with adequate joint locks to tightly join ends of abutting form sections together.

B. Slip Form Construction. Place concrete using an industry-standard slip form paver designed to spread, consolidate, screed, and finish the freshly placed concrete in one complete pass of the machine and with a minimum of hand finishing providing a dense and homogeneous pavement.

Consolidate the full width and depth of concrete pavement placed by a single pass of approved internal vibrators. Operate the vibrators at a frequency range of 7000 to 11,000 impulses per minute. Attach vibrators to either the spreading or finishing equipment in such a manner that they do not come in contact with preset dowel basket assemblies, the subgrade, reinforcing mesh, or side forms. Do not operate vibrators in a manner to cause a separation of the mix ingredients (segregation); i.e., either a downward displacement of large aggregate particles or an accumulation of laitance on the surface of the concrete. Avoidance of segregation may require reduction in the vibration frequency within the range specified when forward motion of the paver is reduced. Connect the power to all vibrators so they stop when the machine motion is stopped. Stop paving operations if any vibrator fails to operate within the above specified range.

Provide an electronic monitoring device that displays the operating frequency of each internal vibrator when paving mainline, ramps, acceleration/deceleration lanes, and collector/distributor lanes. Ensure the monitoring device has a readout display near the paver operator's controls visible to the operator and the Engineer. Operate the monitoring device continuously while paving and display all vibrator frequencies with manual or automatic sequencing among individual vibrators. Using the monitoring system, record the following minimum information: time of day, station location, paver track speed, and the frequency of each individual vibrator. Make recordings after each 25 feet of paving or after 5-minute intervals of time. If not using a monitoring system with a recorder, make and record readings every 30 minutes. Provide vibration data, in electronic format, to the Engineer prior to the next concrete placement.

Electronic vibration monitoring devices are not required for paving machines used to construct shoulders, gores, or for any construction project with a total of less than 10,000 square yards of pavement. When electronic monitoring devices are not required, use a tachometer or similar device to demonstrate to the Engineer the paving equipment vibration meets specification.

Operate the slip form paver with as nearly a continuous forward movement as possible. Coordinate all operations of mixing, delivering, and spreading concrete to provide uniform progress with minimal stopping and starting of the paver. If for any reason it is necessary to stop the forward movement of the paver, immediately stop the consolidation devices. Unless controlled from the machine, do not apply any other tractive force to the machine.

Accurately control the finish grade of the pavement from a pre-set grade line parallel to the finish grade. Use equipment with controls that will trace the grade line and automatically adjust the grade of the screed.

In areas where adjoining concrete pavement is to be constructed, ensure that the surface at the edge of the pavement on either side of the longitudinal joint does not vary more than 1/4 inch below the typical section. Ensure that the outside edges of the pavement does not vary more than 1/2 inch below the typical section. Ensure that all pavement edges are nearly vertical with no projections or keyways exceeding 1/2 inch.

In the area of construction joints placed at the end of the days run, the Engineer will allow a reduction of approximately 2 inches in overall width.

451.05 Setting Forms. Set all forms in conformance to the required grade and alignment. Ensure the entire length of the forms is supported on thoroughly compacted material for the entire operation of placing and finishing the concrete. Set side forms with the top face of the form varying not more than 1/8 inch in 10 feet from true plane, and the vertical face varying not more than 1/4 inch in 10 feet from true plane. Test the forms for variations from the above requirements and reset as necessary. Do not use loose earth, pebbles, etc., to shim the forms. Immediately before placing concrete, the Engineer will approve the alignment and grade of all forms set.

451.06 Fine Grading of Subgrade or Subbase.

A. Fixed Form Construction. After side forms have been set to line and grade and securely fastened, use a subgrade or subbase planer to remove a slight amount of material and bring the surface to final grade and a smooth dense condition. Check the subgrade or subbase using a multiple pin template operated on the forms or other methods approved by the Engineer. Correct and retest all high or low spots.

Instead of the above operation, the Contractor may place forms on subgrade or subbase prepared according to 451.06.B.

B. Slip Form Construction. After the subgrade or subbase is placed and compacted to the required density, use an automatic subgrading machine to cut the areas for pavement and the areas that will support the paving machine to the plan elevation. Construct the grade sufficiently in advance of placing the concrete to permit the Engineer to check the grade.

451.07 Placing Concrete. When constructing on subgrade or subbase, immediately before placing concrete, bring the surface to a thoroughly moistened condition by sprinkling with water as directed by the Engineer.

When constructing on asphalt concrete, coat the surface with curing membrane at least one day prior to placing concrete. Apply the curing membrane at a minimum rate of 1 gallon for each 150 square feet of surface treated using an approved self-propelled mechanical sprayer. Provide an adequate shield to protect the fog spray from the wind. Thoroughly agitate the curing material before use.

Deposit concrete on the grade in a manner that requires as little rehandling as possible. Do not allow workers to walk in the freshly mixed concrete unless wearing clean boots or shoes, free of earth or any foreign material.

When using dowel basket assemblies, place concrete in such a manner that the assemblies are not disturbed. Do not allow concrete to discharge onto any dowel basket assembly unless the hopper is well centered on the assembly. Use a separate internal vibrator to consolidate concrete around dowel basket assemblies.

Provided the curing compound damage caused by sawing is repaired according to 451.11 and to the Engineer's satisfaction, the Contractor may operate the sawing equipment necessary to saw joints on the newly constructed pavement. Do not operate mechanical equipment other than saws on newly placed concrete pavement prior to opening to traffic according to 451.17. If only finishing equipment is carried on an existing lane, paving

adjacent lanes may be permitted after that lane has been in place for at least 3 days and after test cylinders have attained a split tensile strength of 350 pounds per square inch, as tested per ASTM C496.

When the width of pavement being placed in one operation is 12 feet or more and the total area of any given width of pavement on the project exceeds 10,000 square yards and at the direction of the Engineer, use a separate standard manufacture, self-propelled concrete placer/spreader that receives concrete into a hopper adjacent to the area to be paved, delivers the concrete in front of the slipform paver, and uniformly spreads the concrete at the proper thickness for the full width being paved. When a slipform paver is equipped with a dowel bar inserter, the separate placer/spreader requirement may be waived provided the concrete is delivered in front of the slipform paver at a consistent and uniform thickness for the full width being paved and the slipform paver is capable of spreading, consolidating, screeding, and float finishing the freshly placed concrete. Provide the Engineer documentation that the slipform paver will meet this specification.

Do not mix, place, or finish concrete after dark without operating an adequate and approved lighting system.

When the air temperature is 35 °F or below, ensure the concrete has a temperature of between 50 and 80 °F at the point of placement.

When the air temperature is greater than 35 °F before placing, maintain a concrete temperature of not more than 95 °F.

Do not place concrete on any surface that is frozen or has frost.

Make one set of 4 test cylinders for each 100 cubic yards for miscellaneous concrete including but not limited to walls, curbs, and steps, and 250 cubic yards for residential and arterial bases and pavements.

451.071 Depositing and Curing Concrete during Cold Weather. When an atmospheric temperature of 35° F or less exists at the time concrete is placed, or is predicted by weather forecasts to occur during the curing period, the following procedures shall apply:

1. Heat the water or aggregate or both as necessary to make the temperature of the concrete not less than 50° F nor more than 80° F when placed.

2. Once placed, cover the entire surface of the top and the sides of the newly placed concrete and protect from freezing for seven days, unless split tensile specimens have attained the required minimum strength specified. Accomplish protection as directed in 511.12 with insulated blankets or with a combination of loose straw 12 inches thick covered with a securely fastened exterior cover of waterproof material.

3. During the initial 24 hours of protection for base concrete only (Items 305 and 306), the Contractor may use a layer of waterproof material provided the atmospheric temperature is not expected to fall below 25° F and is expected to rise above 35° F during that period. If the temperature falls below 25° F in the initial 24 hours, use full protection as described above.

4. Cure the concrete by maintaining the surface temperature between 50° F and 100° F for a period of not less than 5 days, except as modified below for concrete flooded with water. At the end of this curing period, reduce the temperature at a rate not to exceed 20° F in 24 hours until it is within 20° F at atmospheric temperatures.

5. If High-Early Strength concrete is desired and approved for the placement, the Contractor may use, at no expense to the City, additional cement in combination with calcium chloride in lieu of High-Early Strength Cement, Type III.

6. Furnish and install sufficient thermometers in such a manner that the surface temperature of the concrete may be readily determined. The Engineer will read and record the thermometers.

451.08 Placing Reinforcement. Place pavement mesh of the size and at the locations within the concrete slab shown on ODOT's Standard Drawing BP-1.1. When placing reinforced concrete pavement in two layers, strike off the entire width of the bottom layer to a length and depth that allows laying the mat of reinforcement on the concrete and in its final position without further manipulation. After installing reinforcement directly upon the concrete, place, strike off, and screed the top layer of concrete. When reinforced concrete pavement is placed in one layer and in advance of placing concrete, position and securely anchor the reinforcement to the underlying base or pavement. As an alternative, after spreading the concrete and while it is in a plastic condition, use mechanical or vibratory means to place reinforcement in the concrete.

Where reinforcement is overlapped, securely fasten mats of reinforcement together at the edges of the sheets and at two additional points along the lap. Use reinforcing steel free from dirt, oil, paint, and grease.

451.09 Joints. Unless otherwise directed, construct all transverse joints normal to the centerline of the pavement lane and of the type, dimensions, and at locations specified.

Determine contraction and longitudinal joint sawing time limits to protect the concrete from early cracking. Provided the curing compound damage caused by sawing is repaired according to 451.11 and to the Engineer's satisfaction, the Contractor may operate the sawing equipment necessary to saw joints on the newly constructed pavement.

Accurately mark both edges of the pavement with the correct locations of all joints to be saw cut. Ensure the method of marking remains clearly visible after the paver passes and until the joint saw cut is completed.

A. Longitudinal Joint. Construct longitudinal joints between simultaneously placed lanes by sawing.

When a standard (water cooled diamond bladed) concrete saw is used to make the longitudinal joint between simultaneously placed lanes, saw the joint within three (3) days of placing pavement. For pavement less than or equal to 10 inches, saw the joint to a minimum depth of one-fourth the specified pavement thickness. For pavements greater than 10 inches thick, saw the joint to a minimum depth of one-third the specified pavement thickness. Saw joints 1/4 ± 1/16 inch wide measured at the time of sawing.

When using early-entry (dry cut, light weight) saws to make the longitudinal joint between simultaneously placed lanes, only use saw blades and skid plates as recommended by the saw manufacturer for the coarse aggregate type being used in the concrete. Perform the early-entry sawing after initial set and before final set. Saw the joint 1/8 inch wide and 2 1/4 to 2 1/2 inches deep.

Place deformed epoxy coated steel tiebars, epoxy coated hook bolt with epoxy coated coupling, or epoxy coated hook bolt alternate (wiggle bolt) with epoxy coated coupling, in longitudinal joints during consolidation of the concrete. Install them at mid-depth in the slab by approved mechanical equipment. As an alternate procedure, rigidly secure them on chairs or other approved supports to prevent displacement. Provide tie bars, hook bolts, or wiggle bolts of the size and spaced as shown on the standard drawings. If used, securely fasten hook bolts or wiggle bolts with couplings to the form at the longitudinal construction joint as shown on the Standard Drawings.

B. Transverse Joints. Unless otherwise directed, construct all transverse joints normal to the centerline of the pavement lane and of the type, dimensions, and at locations specified.

For all transverse joints, install round, straight, smooth, steel dowel bars of the size shown in Table 451.09-1.

TABLE 451.09-1 DOWEL SIZE

Thickness of Pavement (T)	Diameter of Solid Dowel
Less than 8 1/2 inches	1 inch
8 1/2 to 10 inches	1 1/4 inches
Over 10 inches	1 1/2 inches

Within 2 hours prior to placing concrete around the dowels, coat the full length of all preset dowels with a thin uniform coat of new light form oil as a bond-breaking material.

1. Load Transfer Assemblies.

Use load transfer (dowel basket) assemblies in transverse contraction joints conforming to and placed according to the standard drawings to hold the dowels in a position parallel to the surface and centerline of the slab at mid-depth of the slab thickness.

Preset all dowel basket assemblies before the day's paving unless the Engineer determines complete presetting is impractical.

Completely install dowel basket assemblies before shipping and spacer wires are removed. Immediately before paving, remove all shipping and spacer wires from the dowel basket assemblies, check that the assemblies are held firmly in place, and check that the dowels are parallel to the grade and parallel to centerline of pavement.

For each load transfer assembly, provide a continuous assembly between longitudinal joints or between the longitudinal joint and pavement edge. Drive at least eight 1/2-inch diameter steel pins a minimum of 18 inches long at an angle to brace the assembly from lateral and vertical displacements during the placing of concrete. Drive two of these pins opposite each other at each end of the assembly, and drive the remaining pins in staggered positions on each side of the assembly. Where it is impractical to use the 18-inch length pins, such as where hardpan or rock is encountered, and provided the assembly is held firmly, the Engineer may authorize use of shorter pins. Where the dowel basket assembly is placed on material that may allow settlement or distortion, anchor the assembly with a combination of pins and steel plates, or by some other means satisfactory to the Engineer to prevent settlement.

When concrete pavement is placed on an existing concrete pavement or on a stabilized base, secure dowel basket assemblies from lateral and vertical displacement during concrete placement using power-driven fasteners and appropriate clips or pins driven in predrilled holes of a diameter slightly less than the pin diameter. Use either of the above methods or a combination of the two in sufficient numbers to adequately secure the basket assemblies.

Where widths other than 12 feet are specified, the Contractor may use standard dowel basket assemblies with dowel spacings adjusted as follows. Maintain 6-inch dowel spacing at the longitudinal joint and increase the spacing at the outer edge of the lane up to 12 inches. Where an odd width of lane occurs and if the standard dowel basket assembly would provide for a space exceeding 12 inches, place a dowel 6 inches from the outer edge of the lane. Hold such a dowel rigidly in proper position by a method satisfactory to the Engineer or cut and splice a dowel basket assembly of greater length than required to attain the required length.

C. Expansion Joints. Where a pressure relief joint is not provided adjacent to a bridge structure, construct expansion joints at the first two regularly spaced joint locations adjacent to the bridge approach slab on each side of the bridge. If the pavement is constructed in two or more separately placed lanes, construct the transverse expansion joints in a continuous line for the full width of the pavement and shoulders.

Construct expansion joints according to the Standard Drawings. Install the face of the expansion joint perpendicular to the centerline except when expansion joint is installed at a skewed bridge approach slab.

Use round, straight, smooth, steel dowels, and within 2 hours of placing concrete, coat the dowels with a thin uniform coat of new light form oil as a bond-breaking material to provide free movement. After coating the dowel, install a sleeve of metal or other approved material approximately 3 inches long, with crimped end, overlapping seams fitting closely around the dowel, and a depression or interior projection to stop the dowel a sufficient distance from the crimped end to allow 1 inch for longitudinal dowel movement with pavement expansion on one free end of each dowel. If approved by the Engineer, use other means to allow for 1 inch of expansion.

Punch or drill proper size dowel holes into the preformed expansion joint filler to assure a tight fit around each dowel.

Form a 1-inch wide and 1-inch deep opening on top of the expansion joint filler and seal this opening with 705.04 joint sealers.

D. Contraction Joint. For pavement less than or equal to 10 inches thick, saw contraction joints with a standard (water cooled diamond bladed) concrete saw to a minimum depth of one-fourth of the specified pavement thickness. For pavement greater than 10-inches thick, saw contraction joints to a minimum depth of one-third the specified pavement thickness. When cutting joints using a standard (water cooled diamond blade) saw ensure the joint is 1/4 ± 1/16 inch wide when measured at the time of sawing.

When using the option of early-entry (dry cut, light weight) saws, only use saw blades and skid plates as recommended by the saw manufacturer for the coarse aggregate type being used in the concrete. Perform the early entry contraction joint sawing after initial set and before final set. Saw the contraction joint 2-1/4 to 2-1/2-inches deep. Ensure any early entry saw joints are approximately 1/8-inch wide at the time of sawing.

If the pavement is constructed in two or more separately placed lanes, install the joints continuous for the full width of the pavement. Saw the pavement with sawing equipment approved by the Engineer as soon as the saw can be operated without damaging the concrete. Provide saws with adequate guides, blade guards, and a method of controlling the depth of cut. After wet sawing, clean the joint using a jet of water. After dry sawing clean the joint using air under pressure. During sawing of contraction joints, maintain a standby saw in working condition with an adequate supply of blades.

E. Construction Joints. Install dowelled construction joints at the end of each day's work and when work is suspended for a period of more than 30 minutes.

Use dowels in transverse construction joints. Within 2 hours prior to placing concrete, coat the free half of all dowels with a thin uniform coat of new light form oil. Use an adequate bulkhead, with openings provided for dowel bars spaced as specified and shaped to fit the typical section of the pavement, to form a straight joint. During placing of concrete, hold dowels rigidly in position.

Locate construction joints at or between contraction joints. If located between contraction joints, construct the construction joint no closer than 10 feet to the last contraction joint.

451.10 Finishing. Use 10-foot straightedges to continually check the finished concrete surface for trueness. If the pavement surface is dragged with a diagonal pipe float machine, occasionally check the surface while the concrete is plastic. Do not add water or finishing agent to aid finishing.

Before the concrete initially sets, round the edges of the pavement along each side of each slab and on each side of transverse expansion joints to the radius specified using an approved edging tool. Before texturing the surface, eliminate tool marks left by the edging tool.

The surface shall be textured by use of a broom or artificial turf drag in the longitudinal direction so as to produce a uniform, gritty, longitudinal texture. In addition to and immediately following the above specified longitudinal drag texture, the pavement shall be textured in the transverse direction by an approved device that will produce a relatively uniform pattern of grooves. The grooves shall be spaced at approximately 3/4 inch centers and shall be approximately 1/8 inch deep and 1/8 inch wide. Variation from the texturing requirements will be permitted only with the written permission of the Engineer.

451.11 Curing. Immediately after the finishing operations have been completed and after all free water has dissipated, spray and seal all exposed concrete surfaces with a uniform application of curing membrane in such a manner as to provide a continuous uniform film without marring the surface of the concrete. Apply a minimum of 1 gallon of material for each 150 square feet of surface treated using an approved mechanical sprayer. Provide an adequate shield to protect the fog spray from the wind. Before each use, thoroughly agitate the curing material.

On pavement with integral curb or small and irregular areas that are inaccessible to the mechanical spray machine, apply the curing material by a hand-held sprayer.

As soon as the forms have been removed, immediately correct all honey-comb areas and coat the edges of the pavement with the curing material.

Respray all areas of curing material film damaged during the sawing of joints.

The Contractor may water cure concrete with wet burlap cloth, waterproof paper, or polyethylene sheeting. Apply curing as soon as possible and without marring the concrete surface. Unless the test cylinders have attained a split tensile strength of 450 pounds per square inch, as tested per ASTM C496, keep the entire surface of the top and sides of the newly placed concrete covered for seven days. Protect concrete from freezing until cylinders attain a split tensile strength of 450 pounds per square inch, as tested per ASTM C496.

The above requirements for curing are minimum requirements only. Repair or replace all concrete showing injury or damage due to insufficient curing at no additional cost to the City.

451.12 Removing Forms. Remove forms in a manner that does not damage the pavement.

451.13 Surface Smoothness. After final concrete curing and cleaning the pavement surface, test the pavement surface for smoothness using a 10-foot rolling straightedge. Provide a two or four-wheeled device with an indicator wheel at the center that detects high and low areas in the pavement surface. Provide equipment that actuates a pointer scale, issues an audio alert, or marks the pavement with paint or dye when encountering any high or low areas in excess of a preset tolerance. Tow or walk the rolling straightedge over the completed pavement. Test all wheel paths in the presence of the Engineer. Locate wheel paths parallel to the pavement centerline and approximately 3 feet measured transversely from the center of the lane. Maintain alignment of the rolling straightedge with reference to the pavement edge at all times.

Correct all surface variations so indicated to within the specified tolerance and in a manner that provides a surface texture conforming to 451.10. For corrective grinding provide equipment conforming to 451.14. Ensure pavement surface variations do not exceed 1/8 inch in a 10-foot length of pavement. For ramp pavements and for those pavements with curvature greater than 8 degrees, or with grades exceeding 6 percent, ensure the surface variations do not exceed 1/4 inch in 10 feet.

Repair or replace sections of pavement containing depressions that cannot be corrected by grinding as directed by the Engineer.

451.14 Profile Grinding. To correct surface variations exceeding tolerances specified in 451.13 use grinding equipment conforming to Item 257.

451.15 Pavement Grooving Corrections. When pavement tining locations are found out of conformance with 451.10 correct the tining using power driven, self-propelled machines specifically designed to groove concrete pavement with diamond impregnated blades or diamond impregnated cylinder rings. Furnish blades or cylinder rings mounted on an arbor head so that the resulting grooves comply with 451.10. Furnish grooving equipment with a depth control device that will detect variations in the pavement surface and enable adjustment of the cutting head to maintain the specified groove depth.

If a pavement area was diamond ground to bring the pavement's surface smoothness within the tolerances of 451.13, that pavement area does not require tining restoration conforming to 451.10.

Vary from these requirements only for small areas and only with written permission from the Engineer.

451.16 Sealing Expansion Joints. As soon as feasible after completing sawing, but before the pavement is open to construction equipment and traffic, seal expansion joints with material conforming to 705.04. Just before sealing, thoroughly clean each joint of all foreign material, using approved equipment. Ensure the joint faces are clean and dry when the seal is installed.

451.17 Opening to Traffic. When 7 days have elapsed, the Contractor may use the completed pavement for traffic, including construction traffic. If a split tensile strength of 450 pounds per square inch, as tested per ASTM C496, has been attained, the Contractor may open the pavement to traffic when 5 days have elapsed. If necessary to open a portion of the pavement in less than 5 days, with the proviso that the pavement will be cured for a minimum of 3 days, use high early strength concrete according to 499.03.C and obtain a split tensile strength of 450 pounds per square inch, as tested per ASTM C496 in 3 days or less.

Pavement Repairs before City Acceptance. Remove and replace or repair diagonal cracks; longitudinal cracks; transverse cracks; spalled pavement surfaces, and any pavement panels with cement balls or mud balls; as approved by and at no cost to the City. Do not repair single hairline transverse cracks in the middle third of panels with reinforcing conforming to BP-1.1. Submit a repair plan with the location, type of repair, materials to be used and procedures to the City for approval. Do not perform any repairs without City approval.

Repair transverse or diagonal cracks with a full depth repair according to Item 255 and applicable Standard Drawings. Repair cracks by replacing the pavement the full width between longitudinal joints, perpendicular to the centerline and at least 6 feet longitudinally. At the direction of the Engineer, install smooth dowel bars at the interface between the original pavement and the replaced pavement section. Locate and size the repairs to ensure that the repair limits are at least 7 feet away from any transverse joint.

Repair longitudinal cracks within 15 inches of a tied longitudinal joint by routing and sealing the crack according to Item 423. For other longitudinal cracks, repair the same as for transverse or diagonal cracks stated above.

Repair spalled pavement with Item 256 Bonded Patching of Portland Cement Concrete Pavement.

Repair all cement balls or mud balls by coring out the area, 1 inch beyond the outside limits of the defective area, with a diamond core bit and replacing the removed concrete with the same concrete as in the pavement. Remove and replace any pavement panel with 5 or more cement balls or mud balls. Locate the limits of the repair along the longitudinal joints and at least 1-foot past the transverse joints to remove any existing dowel bars. Install smooth dowel bars at the transverse limits of the repairs. Install Type D (Drilled Tied Longitudinal) Joint along the longitudinal limits.

451.18 Pavement Thickness and Concrete Strength.

A. Thickness. As determined by measurement of cores cut as specified in this section, construct the concrete not more than 0.2 inch less than the specified thickness. Use cores or cylinders for strength determination as directed by the Engineer. Core pavement at the direction of the Engineer and at locations the Engineer determines according to City Supplement 1064. The Engineer will measure core length according to AASHTO T 148.

For the purpose of coring, the City will consider the entire pavement area of a specified thickness a unit. To determine the number of cores, each pavement unit will be divided into Lots. A Lot consists of 2000 square yards of a pavement unit or major fraction thereof.

Take one random core for each Lot but not less than 3 cores for any pavement unit cored. If a core shows a deficiency in thickness of more than 1/2 inch from the specified thickness, take additional cores to determine the limits of the deficiency. Follow the procedures below:

1. Take a core 5 feet longitudinally on both sides of the deficient core. If both the cores are less than 1/2-inch deficient in thickness, the zone of deficiency has been determined.

2. If either or both 451.18.A.1 cores are more than 1/2 inch deficient in thickness, cut a core 50 feet longitudinally from the deficient core(s). If the 50 foot core(s) is more than 1/2 inch deficient, cut additional cores at 100 foot longitudinal intervals until a core is less than 1/2 inch deficient; until the pavement ends; or until overlapping an adjacent pavement Lot's core in the same lane.

3. If a pavement Lot has cores more than 1/2 inch deficient in thickness and the Lot's constructed width is greater than 12 feet obtain cores transverse to the location of the more than 1/2 inch deficient cores. Obtain transverse cores at a location 1/2 the distance from the deficient core to the furthest edge of pavement. Obtain a transverse core for each core more than 1/2 inch deficient.

4. The Engineer will use the cores that measure less than 1/2 inch deficient in thickness to define the limits of the deficiency.

If any deficient core is greater than 1 inch deficient in thickness determine the limits of over 1 inch deficiency by following 451.18.A.1 through 4 to determine the limits. Remove and replace those areas greater than 1 inch deficient in thickness.

The Engineer will calculate average thickness of concrete pavement placed as follows:

When zones of deficient thickness greater than 1/2 inch to 1 inch are allowed to remain in place, the Engineer will calculate two average thicknesses. A Project Average Thickness (PAT) including all cores not more than 1/2 inch deficient. Cores that exceed the specified thickness by more than 1/2 inch will be considered as the specified thickness plus 1/2 inch when calculating the PAT. A second Deficient Zone Average (DZA) will include all cores with thickness deficiency greater than 1/2 inch to 1 inch. The pavement represented by each of the two averages, PAT or DZA, will be calculated and paid separately.

The City will determine and apply deductions to each separately placed width of pavement.

For any pavement areas removed and replaced, re-core those areas following this section of the specifications. Include those core values into the calculations for average pavement thickness.

Unless the Engineer requests, do not core any widening less than 5 feet in width or any pavement area less than 2000 square yards.

Fill all core holes with concrete of the same proportions and materials used in the pavement.

B. Strength.

The Engineer will calculate average compressive strength of concrete pavement placed as follows:

When zones of deficient strength between 90% to 85% of specified strength are allowed to remain in place, the Engineer will calculate two average strengths. A Project Average Strength (PAS) will include all cores/cylinders exceeding 90% of the specified strength. Cores that exceed the specified strength by more than 10% will be considered as the specified strength plus 10% when calculating the PAS. A second Deficient Strength Zone Average (DSZA) will include all cores/cylinders with strengths between 90% and 85% of the specified strength. The pavement represented by each of the two averages, PAS or DSZA, will be calculated and paid separately.

Any area represented by cores/cylinders with a strength of less than 85% of the specified strength shall be removed and replaced.

451.19 Price Adjustments. Based on the Pavement Average Thickness and Pavement Average Strength, the City will make payment as specified in Tables 451.19-1 and/or 451.19-2.

A. Pavement Thickness. Price adjustments for thickness deficiencies will be calculated according to Table 451.19-1.

TABLE 451.19-1
CONCRETE PAVEMENT THICKNESS PAY FACTOR (PF_T)

Deficiency in Thickness as Determined by Cores	Proportional Part of Contract Price
0.0 to 0.2 inch	100 percent
0.3 to 0.5 inch	$Ratio\ \left[\frac{PAT}{PST}\right]^6$
0.6 to 1.0 inch*	$Ratio\ \left[\frac{DZA}{PST}\right]^6$
Greater than 1.0 inch	Remove and replace

* The Engineer will determine whether pavement areas from 0.6 inch to 1 inch deficient in thickness will be allowed to remain in place at the reduced price or must be removed and replaced.
PAT = Project Average Thickness
PST = Plan Specified Thickness
DZA = Deficient Zone Average

B. Pavement Strength. Price adjustments for strength deficiencies will be calculated according to Table 451.19-2.

TABLE 451.19-2
CONCRETE PAVEMENT STRENGTH PAY FACTOR (PF_S)

Percent of Compressive Strength as Determined by Cores/Cylinders	Proportional Part of Contract Price
100% to 95%	100 percent
94.9% to 90.0%	$Ratio\ PASPSS6$
89.9% to 85.0%*	$Ratio\ DSZAPSS6$
Less than 85%	Remove and replace

* The Engineer will determine whether pavement areas with strengths from 85% to 90% of the specified strength will be allowed to remain in place at the reduced price or must be removed and replaced.
PAS = Project Average Strength
PSS = Plan Specified Strength
DSZA = Deficient Strength Zone Average

C. Multiple Deficiencies. When a pavement exhibits multiple deficiencies for thickness and strength, the reduced unit price will be calculated for each deficiency and the lowest reduced unit price will be used.

451.20 Method of Measurement. The City will measure Reinforced Concrete Pavement by the number of square yards completed and accepted in place. The width equals the pavement width shown on the typical cross-section of the plans plus additional widening as the Engineer directs in writing. The City will field measure the length along the centerline of each roadway or ramp. The City will determine the area based on the above width and length.

451.21 Basis of Payment. Payment is full compensation for furnishing and placing all materials including reinforcing steel, dowels, and joint materials; for furnishing the 10-foot rolling straightedge; and for coring and testing the pavement. For pavement found deficient in thickness or compressive strength, the City will pay a reduced price according to 451.19.

The City will not pay extra for pavement with an average thickness in excess of that shown on the plans.

The City will pay for accepted quantities at the contract price as follows:

Item	Unit	Description
451	Square Yard	Reinforced Concrete Pavement Class ____

ITEM 452 NON-REINFORCED PORTLAND CEMENT CONCRETE PAVEMENT

452.01 Description
452.02 Construction
452.03 Method of Measurement
452.04 Basis of Payment

452.01 Description. This work consists of constructing a non-reinforced portland cement concrete pavement on a prepared surface.

452.02 Construction. The requirements of Item 451 apply, except as follows.

Do not comply with the requirements of 451.08.

Provide dowels at transverse contraction joints in mainline pavement, ramps, acceleration/deceleration lanes, or collector/distributor lanes. Dowels for contraction joints in concrete shoulders on mainline pavement, ramps, acceleration/deceleration lanes, or collector/distributor lanes are not required unless the contraction joint is located within 500 feet of a pressure relief joint.

Space contraction joints according to the Standard Drawings. If Item 452 pavement is specified for shoulders and is tied longitudinally to Item 451 or Item 305 pavement, match the joints in the shoulder pavement to the spacing and alignment of the adjacent pavement.

Do not place construction joints within 6 feet of another parallel joint.

If making pavement repairs before City acceptance under 451.17, repair all cracks exclusive of size or location.

452.03 Method of Measurement. The City will measure Non-Reinforced Concrete Pavement by the number of square yards completed and accepted in place. The width equals the pavement width shown on the typical cross-sections of the plans plus additional widening as the Engineer directs in writing. The City will field measure the length along the centerline of each roadway or ramp.

452.04 Basis of Payment. Payment is full compensation for furnishing and placing all materials, for surface testing, and for coring the pavement. For pavement found deficient in thickness or compressive strength, the City will pay a reduced price according to 451.19.

The City will not make additional payment over the contract unit price for any pavement with an average thickness in excess of that shown on the plans.

The City will pay for accepted quantities at the contract price as follows:

Item	Unit	Description
452	Square Yard	Non-Reinforced Concrete Pavement, Class _____

ITEM 454 PAVEMENT RELIEF JOINTS

454.01 Description
454.02 Materials
454.03 General
454.04 Placement
454.05 Method of Measurement
454.06 Basis of Payment

454.01 Description. This work consists of constructing pavement relief joints composed of asphalt concrete on a prepared subgrade.

454.02 Materials. Furnish asphalt concrete conforming to Item 441 Asphalt Concrete, Intermediate Course, Type 2.

454.03 General. Construct pavement relief joints with all portland cement type pavements or bases, in accordance with Standard Drawing 2175 and this specification. Each pavement relief joint shall be 4 feet long and extend between pavement edges, curbs or gutters. Place 2 inches of

expansion joint material in the curb or curb and gutter at and centered on the relief joint. Place the Item 441 Asphalt Concrete, Intermediate Course, Type 2 in lifts no greater than the thickness of the pavement or base divided by 3; however, do not exceed 3 inches in any lift. Construct the pavement relief joint flush to the top of the portland cement concrete pavement or base.

454.04 Placement. Construct pavement relief joints as follows:

1. At the P.C. and P.T. for all pavement sections with a centerline radii less than or equal to 500 feet and deltas greater than 50 degrees.
2. At least one between intersections, including T type. Construct additional pavement relief joints when the distance within any one block exceeds 800 feet; space these additional pavement relief joints a minimum of 400 feet apart and not to exceed 800 feet.
3. Whenever a new roadway adjoins an existing roadway, begin this work with a pavement relief joint.
4. Plan pours of pavements or bases in such a manner so as to end a day's work at a pavement relief joint.

454.05 Method of Measurement. The City will measure the actual linear feet of Pavement Relief Joint accepted in place as measured between curbs and perpendicular to the centerline of the pavement.

454.06 Basis of Pavement. The City will pay for accepted quantities complete in place, at the contract price as follows:

Item	Unit	Description
454	Linear Feet	Pavement Relief Joint

ITEM 499 CONCRETE—GENERAL

499.01 Description
499.02 Materials
499.03 Concrete Mix Designs
499.04 Adjustments and Controls
499.05 Equipment
499.06 Handling, Measuring, and Batching Materials
499.07 Batch Plant Tickets
499.08 Mixing Concrete

499.01 Description. This specification consists of proportioning requirements for Portland concrete mix designs, mixing, and controls of Portland cement concrete.

499.02 Materials. Furnish materials conforming to:

Portland cement.....701.01, 701.02, 701.04
..... 701.05 and 701.09 or blended cement [1]
Microsilica 701.10
Ground granulated blast furnace slag (GGBFS) [6].....
..... .701.11
Fly ash..... 701.13
Fine aggregate [2] [3] 703.02
Coarse aggregate [3]..... 703.02, 703.13 [4]
Air-entraining admixture 705.10
Chemical admixture for concrete [5]..... 705.12
Carbonate Micro-Fines..... 701.14

[1] If blended cement is used, provide mill certification of all the cement and pozzolanic components and final product for approval by the Laboratory.

[2] 703.02 natural sand or sand manufactured from stone as specified in 703.02.A.3 is required in Item 255, 256, 451, 452, 526, and 511 deck slabs.

[3] Aggregates may be standard gradation sizes from 703.02 and Table 703.01-1 or they may be a modified gradation defined with the mix design submittal and certified by the Laboratory under City Supplement 1069.

[4] Applies only to 305, 306, 451 and 452 concrete.

[5] Admixtures shall contain no more than 50 parts per million chloride ions by weight of cement except for Type C accelerating admixtures or calcium chloride for COC FS only.

[6] To be used only for 305, 306, 307, 451, 452 concrete.

Use water for concrete mixing free from sewage, oil, acid, strong alkalis, vegetable matter, clay, and loam. Potable water is satisfactory for use in concrete. Non-potable water will meet the requirements of ASTM C1602. Water from a reclaiming system will contain no more than 0.06% chlorides. Test the non-potable water monthly and maintain data verifying that the water meets the requirements. Provide the data at the Engineer's request.

499.03 Concrete Mix Designs. Develop concrete mix designs according to ACI 301, Section 4 meeting the requirements of Table 499.03-1. Limit the pozzolan content of any mix design according to Table 499.03-2. The design air for concrete with 1" nominal maximum size aggregate is 7%. Develop concrete mix designs per this specification and City Supplement 1126.

Only use mix designs accepted by the City and issued a JMF number.

TABLE 499.03-1 CONCRETE MIX DESIGN REQUIREMENTS Quantities Per Cubic Yard Provide Concrete with 7±2% Air Content					
Class	**Previous Class [8]**	**Design Strength psi**	**Permeability [1] Maximum (Coulombs)**	**Cementitious Content [2] Minimum. lbs**	**Aggregate Requirements**
COC 1	New	4,000 at 28 days	2,000	520	Well-Graded
COC 2	New	4,500 at 28 days	1,500	520	Well-Graded
COC 3 Special	New	As per plan	1,500 or as per plan	520 or as per plan	Well-Graded or as per plan
COC 4 Mass Concrete	New	4,000 or as per plan [3]	2,000 or as per plan	470 [4] [5] or as per plan	Well-Graded or as per plan
COC 5 [7]	Class S	4,500 at 28 days	N/A	520	1 inch or 3/8 inch nominal maximum size
COC 6	Class C	4,000 at 28 days	N/A	550 [6]	1 inch nominal maximum size
COC 7	Class F	3,000 at 28 days	N/A	420 [6]	1 inch nominal maximum size
COC 8	Class A	Unspecified	N/A	280	1 inch nominal maximum size
COC MS	MS	See City Supplement 1126	N/A	800	1 inch nominal maximum size
COC FS	FS	See City Supplement 1126	N/A	900	1 inch nominal maximum size

[1] AASHTO T277 Modified.
[2] Cementitious Content includes cement, pozzolan, and carbonate micro-fines materials, denoted as Cm.
[3] Strength for Mass Concrete (COC 4) may be tested at either 28 or 56 days.
[4] Do not use Type III cement or accelerating admixtures in mass concrete.
[5] The maximum fly ash or GGBFS content may be increased up to 50%.
[6] Cement or a combination of cement and up to15% fly ash or up to 30% GGBFS.
[7] For COC 5 mixes with 3/8 inch nominal size, provide an air content of 8±2%.
[8] Class designation from 2012 CMSC book.

Determine the permeability by testing according to AASHTO T277 except moist cure the permeability samples for 7 days at 73 °F followed by 21 days of moist curing at 100 °F. Perform permeability testing at 28 days.

Limit pozzolan materials as a percent of total cementitious content according to Table 499.03-2:

TABLE 499.03-2 POZZOLAN MATERIALS

MATERIAL	MAXIMUM CONTENT (%)
Fly Ash	25
GGBFS	30
Micro-Silica	10
Carbonate Micro-Fines [1]	20
When using multiple pozzolan materials, do not exceed the individual maximum contents above for each material. A combination of pozzolan materials may not exceed 50% of the total cementitious content by weight.	
[1] Not for use in COC 2 or COC 3 concrete.	

A. Slump. Maintain slump within the nominal slump range in Table 499.03-3. If below the maximum water-cementititous ratio of the Job Mix Formula (JMF), adjust the quantity of water to meet slump requirements. Do not use concrete with a slump greater than the maximum shown in Table 499.03-3.

TABLE 499.03-3 CONCRETE SLUMP

Type of Work	Nominal Slump Inch [1]	Maximum Slump Inch [2]
Concrete pavement (305, 306, 451, 452, 615)	1 to 3	4
Structural Concrete (511, 610, 622)	1 to 4	5
Superstructure concrete (511, 526)	2 to 4	4
Non-reinforced concrete (601, 602, 603, 604, 608, 609, 622)	1 to 4	5
[1] This nominal slump may be increased to 6 inches, provided the increase in slump is achieved by adding a chemical admixture conforming to the requirements of 705.12, Type F or G.		
[2] This maximum slump may be increased to 7 inches, provided the increase in slump is achieved by adding a chemical admixture conforming to the requirements of 705.12, Type F or G.		

B. Air Content. Ensure that the air content in all concrete at the point of placement is within the percentage range specified in Table 499.03-1.

499.04 Adjustments and Controls. Provide the following adjustments and controls during batching and placement of the concrete:

A. Batch the concrete to the proportions of the accepted JMF. Provide a workable and finishable mix. Adjustments to the JMF's aggregate proportions up to 100 lbs for workability may be made. Adjustments greater than 100 lbs may be made if approved by the Engineer. Maintain an absolute volume of 27.0 cubic feet/cubic yard for the adjusted concrete mix. For Well Graded JMF adjustments, maintain the combined aggregate gradation within the optimal zone II requirements for well-graded mixes as defined in City Supplement 1126. If outside the optimal zone II of the Coarseness Factor Chart adjust the JMF's proportions to maintain the combined gradation within Zone II and report the JMF changes to the Engineer.

B. Handle, haul and store aggregates to minimize segregation, avoid contamination, and assure a uniform grading within the specified gradation. Do not combine aggregates from different sources or of different gradings in the same stockpile. Do not use segregated or contaminated aggregates.

C. Remove all wash water by reversing each truck drum at the plant immediately prior to reloading.

D. Adjust the SSD aggregate design weights in the JMF to compensate for the moisture contained in the aggregates and moisture the aggregates will absorb during batching. Adjust the mix water to compensate for the aggregate moistures.

E. Use only compatible admixtures in the concrete. Dispense all admixtures according to the manufacturer's recommendations. Furnish a volumetric dispenser for the Type F or G admixture or ensure that there is a gage on each truck-mounted Type F or G admixture dispensing tank. If any admixture is added at the job site, mix the load for a minimum of 5 minutes.

F. Do not exceed the maximum water/cementitious ratio of the accepted JMF. Use a water-reducing admixture conforming to 705.12; proportionately increase the cementitious content; or develop and submit for acceptance a new JMF. Adjust the absolute volume of the aggregates if the cement content is increased.

G. If during placement of concrete, cement or microsilica balling is observed, take corrective action with further mixing. If after corrective action, balling continues, reject the load. Revise the mixing process and/or loading sequence to prevent further balling.

H. If slump loss occurs before placement of the concrete, the concrete may be "replasticized" with an admixture to restore plasticity. The Engineer will recheck the slump range and air content to ensure conformance to the specifications. If after "replasticizing" the components of the load are segregated, the City will reject the load.

I. Completely discharge the concrete from each delivery truck within the time requirements of 499.08.

J. Provide sufficient quality control at the plant to assure conformance with this specification and project requirements.

K. Use an approved set-retarding admixture conforming to 705.12, Type B or D when the concrete temperature exceeds a nominal temperature of 75° F.

499.05 Equipment. Use a City approved batch plant and trucks. Provide batching and mixing equipment meeting the following requirements:

A. Batching Plants. Operate each plant so that aggregate materials are not segregated and there is no intermingling of the materials before batching. Use weighing mechanisms that allow a visible means of checking weights and produce a printed record. Use dispensing mechanisms for water and admixtures that allow a visible means of checking quantities and produce a printed record.

Use cement and aggregate weighing mechanisms that are accurate to within ±0.5 percent of the correct weight. Ensure that devices for weighing or metering water are accurate to ±1.0 percent throughout the range used.

Maintain a certification from a Sealer of Weights and Measures or a scale servicing company attesting to the accuracy of the weighing and metering devices. A Certificate of Performance issued by the National Ready Mixed Concrete Association may be used instead of the Sealer of Weights and Measures or a scale servicing company. Do not use plants with a certification or certificate older than 12 months.

Maintain the services of a scale servicing company or ten standard test weights to reach a capacity of 500 pounds for testing the weighing devices at the batch plant. Ensure all device-testing weights are sealed by the Ohio Department of Agriculture every 3 years.

The Engineer may test weighing and dispensing devices as often as necessary to ensure continued accuracy.

B. Mixers. Provide mixers and agitators conforming to AASHTO M 157, Sections 10, 11.2, 11.5, and 11.6, except that the City will allow mechanical counters.

For bodies of non-agitating concrete hauling equipment, provide smooth, mortar-tight, metal containers capable of discharging the concrete at a satisfactory controlled rate without segregation. Provide covers when required by the Engineer. The Engineer will allow trucks having dump bodies with rounded corners and no internal ribs or projections for non-agitating hauling.

C. Concrete Pumping and Conveying Equipment. Provide concrete pumping and conveying equipment in accordance with ACI 304.2R and ACI 304.4R. Conduct a pre-placement meeting to discuss concrete pumping and conveying procedures to maintain air content within specified limits per Table 499.03-1.

499.06 Handling, Measuring, and Batching Materials. Do not stockpile aggregates from different sources or different gradations together. Do not use aggregates that have become segregated or mixed with foreign material. The Engineer may direct reworking or cleaning, or may reject aggregates that have become segregated or mixed with earth or foreign material.

Prior to and during batching, maintain all coarse aggregates at a uniform moisture content.

For all slag aggregates or other aggregates with a reported absorption above 3.0 percent, maintain the moisture contents at or above the ODOT-reported SSD for that aggregate as follows:

A. Use appropriate stockpile watering systems capable of raising and maintaining aggregate moisture at or above SSD. Test the moisture content of the watered aggregate stockpiles in at least five (5) locations to assure the stockpile is at or above SSD.

B. Have processes to maintain the aggregate stockpile at SSD until stockpile draining for SSD consistency has begun. Twenty-four (24) hours before batching concrete with the aggregate, shut down the stockpile watering process to allow drainage and to establish a uniform moisture content.

C. Test aggregate moisture content at least once per half day, but not less than twice per day, during concrete production. If the moisture content varies between tests by more than 1 percent increase the moisture testing frequency to assure correct batching information.

D. Provide the moisture content test results as part of all quality control plant ticket information.

Separately weigh the amounts of fine aggregate and coarse aggregate. Use a separate weighing device for cementitious materials.

Batch each material to ensure weights are within the tolerance specified in Table 499.06-1, based on the amount specified in the approved JMF.

TABLE 499.06-1 CONCRETE BATCHING TOLERANCES

Material	Batching Tolerance (%)
Cement	±1.0
Pozzolan	±1.0
Carbonate Micro-Fines	±1.0
Aggregates	±2.0
Water[1]	±1.0
Chemical Admixtures	±3.0

[1] Measured by weight or volume

499.07 Batch Plant Tickets. Furnish a concrete batch plant ticket to the Engineer for each load of concrete incorporated into the project. Provide computer generated batch tickets. At a minimum, include the information listed in Table 499.07-1 on each ticket:

TABLE 499.07-1 EVERY BATCH TICKET

Name of ready-mix batch plant	
Batch plant No.	
Batch plant location	
Serial number of ticket	
Date	
Truck number	
Class of concrete	
JMF Number	
Batch time	
Batch size	yd^3
Actual weights of cementitious material:	
Cement	lb
Fly ash	lb
GGBFS	lb
Microsilica	lb
Carbonate Micro-Fines	lb
Other	lb
Actual weights of aggregates:	
Coarse	lb
Intermediate	lb
Fine	lb
Other	lb
Actual weight of water	lb
Actual volume of admixtures:	
Air-entrainer	fl oz
Superplasticizer	fl oz
Water-reducer	fl oz
Retarder	fl oz
Other	fl oz
Aggregate moisture contents:	
Coarse aggregate	%
Intermediate aggregate	%
Fine aggregate	%
Water-cementitious ratio, leaving the plant	

Provide the information in Table 499.07-2 with batch tickets for each day's first load of concrete and for each JMF. Include Table 499.07-2 information on the batch ticket or furnish the information on a separate computer-generated or handwritten form attached to the batch ticket.

If during the concrete manufacturing process any of the information listed in Table 499.07-2 changes, resubmit Table 499.07-2 information with the first batch ticket supplied with the changed concrete.

TABLE 499.07-2 FIRST TICKET EACH DAY, EACH JMF

Cementitious Materials:	**Source:**	**Grade or Type:**
Cement		
Fly ash		
GGBFS		
Microsilica		
Carbonate Micro-Fines		
Other		
Admixtures	**Brand:**	**Type:**
Air-entrainer		
Retarder		
Superplasticizer		
Water-reducer		
Other		

Provide concrete batch ticket information according to ASTM C 94/C 94M, Section 13.

The Engineer may require supporting data to validate the basis for furnished aggregate moisture contents.

499.08 Mixing Concrete. Use a central mix plant or in truck mixers to mix the concrete.

When using a central mix plant, mix the concrete not less than 60 seconds. Begin the mixing time when all materials are in the drum and end the mixing time when discharge begins. Include transfer time in multiple drum mixers in the mixing time. Remove the contents of an individual mixer drum before a succeeding batch is emptied into the drum.

When concrete is mixed using a truck mixer for complete mixing, mix each batch of concrete at the rotation rate designated on the mixer as mixing speed for not less than 70 revolutions of the drum. Transport mixed concrete from the central mixers in truck mixers, truck agitators, or trucks having non-agitating bodies. Within 90 minutes after cement and water are combined, deliver and completely discharge concrete.

When concrete is delivered in transit mixers and before discharging any of a batch, the Engineer may allow adding water within the specified water-cement ratio limits. Perform sufficient mixing, a minimum of 30 revolutions at mixing speed, to adjust the slump and to regenerate the specified air content throughout the batch.

When approved by the Engineer, the Contractor may use approved admixtures (705.12, Type F or G) for retempering the load to adjust the slump after the start of discharge. Mix for a minimum of 30 revolutions at mixing speed after addition of the admixture.

Use admixtures containing no more than 50 parts per million chloride by weight of cement only when specified in the Contract Documents, the accepted JMF, or with the Engineer's written permission.

Ensure that the temperature of all concrete does not exceed 90°F until incorporated into the work.

500 STRUCTURES

ITEM 501 STRUCTURES—GENERAL

501.01 General
501.02 Verification of Dimensions
501.03 Notification of Fabricator
501.04 Shop Drawings
501.05 Submittal of Engineered Drawings
501.06 Test Reports
501.07 Welded Attachments

501.01 General. This specification includes the general requirements for building the various items that constitute the completed structure.

Perform the work, including fabrication, erection, and construction, so that the entire structure and all its component parts will function as designed.

501.02 Verification of Dimensions. Verify that all dimensions established by the Engineer are correct.

501.03 Notification of Fabricator. When furnishing materials under Items 513, 515, 516, 517, and 518, select a fabricator from the Ohio Department of Transportation's pre-qualified fabricators list in effect the date of the Contract letting. Before or at the preconstruction conference, provide a written notification to the City of the selected steel fabricators and precast concrete fabricators.

501.04 Shop Drawings. Provide shop drawings detailing structural steel, metal structural elements, prestressed concrete members, precast concrete structural elements, and other similar materials requiring either shop or field fabrication. Include the Project Number.

A. Contractor Acceptance of Shop Drawings for Items 513 and 515. Submit shop drawings to the Engineer before the start of fabrication on Item 513, UF Level or at least 3 days before the pre-fabrication meeting, per 513.07 or 515.07 as follows:

For structures carrying railroad traffic, submit four copies of the prepared shop drawings at least 40 days prior to the pre fabrication meeting to each railroad company involved for review and approval. Resolve all railroad comments prior to submitting drawings to the Engineer. The submission to the Engineer shall include one set of shop drawings accepted by each railroad company involved; copies of all documentation between the railroad(s) and the Contractor; four sets of Contractor accepted shop drawings, and the Contractor's written acceptance letter. Also furnish the fabricator's quality control specialist with one additional set of these drawings before the pre-fabrication meeting.

For all other structures, the submission to the Engineer shall include a written acceptance letter and four copies of each drawing, unless additional copies are requested. Also, furnish the fabricator's quality control specialist with one additional set of these drawings before the pre-fabrication meeting.

Have competent individuals prepare and check the shop drawings. The preparer(s) and checker(s) shall initial each sheet and shall be different individuals. Provide, on the submittal letter, the first name, last name and initials of each preparer and checker performing work on the shop drawings. Have an Ohio Registered Engineer sign, seal and date the shop drawing submittal letter according to ORC 4733 and OAC 4733-35 confirming that the shop drawings meet the intent of the contract. If multiple preparers or multiple checkers created the drawing, then the submittal letter shall clearly indicated the portions for which each person is responsible. Have all questions and comments addressed before submitting the shop drawings.

The Contractor's written acceptance letter shall document acceptance of the shop drawings including confirmation of field verification, as required, and descriptions of issues resolved between the Contractor, the fabricator, or the City.

By accepting these shop drawings, the Contractor represents to the City that all dimensions and elevations of existing conditions shown on the plans have been field measured and verified, and that these shop drawings comply with all the materials requirements, construction requirements, contract requirements, and performance criteria. The Contractor further represents that these drawings have been coordinated and verified with the details of the work to be performed by other fabricators and entities on the project. The City will not make any allowance for additional cost or delays to the Contractor for incorrect fabrication as a result of failure to coordinate or perform this acceptance.

If the City requests changes on these shop drawings, or the Contractor makes changes in addition to those expressly requested, revise the shop drawings and submit a new cover sheet, signed, sealed and dated by an Ohio Registered Engineer with suitable revision marks to identify the changes.

Schedule the pre-fabrication meeting after the Engineer receives the drawings. Fabrication may begin after the pre-fabrication meeting is complete or after receipt of Item 513, UF Level drawings.

B. Fabricator Coordination of Shop Drawings for Items 516, 517, and 518. The Contractor and fabricator must coordinate these shop drawings. Ensure that shop drawings meet requirements for materials, field measurements, construction requirements, contract requirements, performance criteria, and similar data. The coordination must also include details of the work to be performed by other fabricators and entities on the project. The City will not make allowance for additional cost or delays to the Contractor for incorrect fabrication as a result of failure to coordinate or perform this coordination.

Submit an electronic copy of the shop drawings to the Engineer prior to the materials being delivered to the project. Do not incorporate material into the work until after submitting the drawings. City approval of these shop drawings is not required.

C. Shop Drawing General Requirements. Specific requirements are specified in Items 513, 515, 516, 517, or 518.

Shop drawings shall be neatly and accurately drawn on 11 x 17 inch or 22 × 34inch sheets. Submit the shop drawings electronically in pdf format.

501.05 Submittal of Engineered Drawings. Design and perform all procedures as directed by the *AASHTO Standard Specifications for Highway Bridges* or the *AASHTO LRFD Bridge Design Specifications* except as modified below:

Perform daily inspections to ensure the work governed by the Engineered Drawing is functioning as designed. Report malfunctioning work to the Engineer immediately.

A. Projects with Railroad Involvement. Prepare and provide Engineered Drawings listed in this section as follows:

Have competent individuals prepare, check and initial each Engineered Drawing. The preparer and checker shall be different individuals. Provide, on the submittal letter, the first name, last name and initials of each preparer and checker performing work on the Engineered Drawings. Have an Ohio Registered Engineer sign, seal, and date the submittal letter according to ORC 4733 and OAC 4733-35. If multiple preparers or multiple checkers created the drawing, then the submittal letter shall clearly indicate the portions for which each person is responsible.

Submit Engineered Drawings to all involved railway companies at least 50 days before planned construction begins. Obtain acceptance from all involved railroad companies. Furnish the Engineer copies of all correspondence with the railroad, documentation of railroad acceptance and the Engineered Drawings accepted by the railroad.

Schedule an Engineered Drawing meeting to be held 7 days, or less at the discretion of the Engineer, after submitting railroad accepted drawings to the Engineer. The signatory Engineer responsible for the Engineered Drawing design, the Superintendent, the Engineer and the Inspector will participate in the meeting in person, via conference call or via video conference. The Engineer may invite the responsible designer of the Plans for assistance. The purpose of the meeting shall be to review the drawings; resolve all issues to the Engineer's satisfaction and ensure all parties are in agreement with the work to commence. At the conclusion of the meeting, the Engineer will provide a written response to the submittal in accordance with 105.02. Do not begin work until the Engineer's acceptance has been received.

Perform all work in accordance with the accepted Engineered Drawings. Immediately cease all operations that deviate from the accepted Engineered Drawings. If a deviation is necessary, prepare revised Engineered Drawings as noted above and furnish the Engineer a copy of revised Engineered Drawings including documentation of acceptance from all involved railroad companies. Schedule an Engineered Drawing meeting as noted above to be held 24 hours, or less at the discretion of the Engineer, after submitting the revised railroad accepted drawings. At the conclusion of the meeting, the Engineer will provide a written response to the submittal in accordance with 105.02. Do not begin work until the Engineer's acceptance has been received.

The City will consider delays resulting from Engineered Drawing deviations as non-excusable in accordance with 108.06.E.

This section applies to Engineered Drawings for the following:

1. Bracing adjacent to the railroad tracks. Perform work according to 501.05.B.1.
2. Demolition of structures over or within 14 feet of railroad tracks. Perform work according to 501.05.B.2.
3. Erection of structural members over or within 14 feet of railroad tracks. Perform work according to 501.05.B.4.

B. Projects without Railroad Involvement. Prepare and provide Engineered Drawings listed in this section as follows:

Have competent individuals prepare, check and initial each working drawing. The preparer and checker shall be different individuals. Provide, on the submittal letter, the first name, last name and initials of each preparer and checker performing work on the working drawings. Have an Ohio Registered Engineer prepare, sign, seal and date the submittal letter according to ORC 4733 and OAC 4733-35. If multiple preparers or multiple checkers created the drawing, then the submittal letter shall clearly indicate the portions for which each person is responsible.

Schedule an Engineered Drawing meeting to be held 7 days, or less at the discretion of the Engineer, after submitting drawings to the Engineer. The signatory Engineer responsible for the design, the Superintendent, the Engineer and the Inspector will participate in the meeting in person, via conference call or via video conference. The Engineer may invite the designer of the contract Plans for assistance. The purpose of the meeting shall be to review the drawings; resolve all issues to the Engineer's satisfaction and ensure all parties are in agreement with the work to commence. At the conclusion of the meeting, the Engineer will provide a written response to the submittal in accordance with 105.02. Do not begin work until the Engineer's acceptance has been received.

Perform all work in accordance with the accepted Engineered Drawings. Immediately cease all operations that deviate from the accepted Engineered Drawings. If a deviation is necessary, prepare revised Engineered Drawings as noted above and furnish the Engineer a copy of revised Engineered Drawings. Schedule an Engineered Drawing meeting as noted above to be held 24 hours, or less at the discretion of the Engineer, after submitting the revised drawings. At the conclusion of the meeting, the Engineer will provide a written response to the submittal in accordance with 105.02. Do not begin work until the Engineer's acceptance has been received.

The City will consider delays resulting from Engineered Drawings deviations as non-excusable in accordance with 108.06E.

This section applies to Engineered Drawings for the following:

1. Cofferdams and Excavation Bracing. If a complete design is not provided in the plans, provide Engineered Drawings for excavations when the edge line of a roadway used to maintain traffic is located within a distance of one-half times the excavation height or for excavations that expose any side of an excavation to a height exceeding eight feet.

The Contractor may construct the design(s) shown on the plans without an Engineered Drawing submittal or prepare an alternate design. Submit Engineered Drawings for all alternate Cofferdam and Excavation Bracing designs. Perform all Work as specified below:

a. Locate Cofferdams and Excavation Bracing according to the contract, if shown.

b. Maintain temporary horizontal and vertical clearances according to the contract.

c. Include the effects of AASHTO live, dead and temporary construction load surcharges as necessary.

d. Design Cofferdams and Excavation Bracing to support the sides and bottom of an excavation for all phases of work in accordance with the latest *AASHTO Guide Design Specifications for Bridge Temporary Works*, Section 4 and the latest edition of either the AASHTO LRFD Bridge Design Specifications or the AASHTO Standard Specifications for Highway Bridges.

2. Demolition of Bridges or portions of Bridges in which the work endangers the public welfare, or life, health or property. Perform all work as specified below:

a. Provide temporary devices or structures necessary to protect traffic during all demolition activities. Provide traffic protection when demolition is located less than 12' horizontally from active traffic on structures of less than 25' vertical clearance. Increase the 12' minimum horizontal distance 1 foot for each 2 feet of additional height greater than 25'.

b. Never lift the portions of structure being removed over active traffic. Before releasing traffic make the remaining structure stable.

c. Design traffic protection devices or structures for a minimum load of 50 pounds per square foot plus the weight of equipment, debris and any other load to be carried. Include any portion of the deck that cantilevers beyond the fascia beams or girders.

d. In lieu of temporary devices or structures required in "a" above, provide a vertical barrier. Design the vertical barrier with rigid or flexible materials specifically designed for demolition containment. Extend the enclosure up to the bottom of the deck and down to the ground. Maintain all materials free of tears, cuts and holes.

e. Maintain temporary horizontal and vertical clearances according to the contract.

f. Locate structural members to be reused before performing any removal operations.

g. Do not damage structural members being reused during any removal operation.

h. Perform Work so that all members are stable during all operation and loading conditions.

i. Provide the method and sequence of the removal operations. Include the type and location of equipment to be used during the demolition.

j Perform work according to 501.05.B.6.

3. Falsework for cast-in-place concrete slab bridges. Perform all work according to Item 508 and as specified below:

a. Provide a camber table to account for the deflection of the falsework loaded with its self-weight and the weight of wet concrete. Also include in the table, the specified camber to compensate for slab deflection after the falsework is released.

b. Maintain temporary horizontal and vertical clearances according to the contract.

c. As a minimum, design falsework over waterways for a five year flood or with 75 percent of the effective waterway opening of the proposed structure. The Contractor is responsible for any damages caused by upstream flooding due to insufficient temporary structure size or the accumulation of debris or sediment in the channel.

d. Support falsework foundations located within the ten year flood limits on rock, shale or piles driven to a minimum depth of 15 feet, and to sufficient penetration to carry superimposed loads or until refusal on rock.

e. The incorporation of structural steel shapes, used as temporary support members, into a finished concrete slab superstructure is prohibited.

f. Design falsework in accordance with the latest *AASHTO Guide Design Specifications for Bridge Temporary Works*, Section 2.

4. Erection of steel or precast concrete structural members as specified below:

a. Never lift structural members over active traffic. Before releasing traffic make structural members stable.

b. Supply any temporary supports or braces necessary to maintain structural stability and prevent lateral movement until completion of all construction activities.

c. Perform work according to 501.05.B.6, Item 513 or Item 515.

d. Do not field weld temporary members to permanent steel members.

e. Maintain temporary horizontal and vertical clearances according to the contract.

f. Provide drawings with at least the following information:

i. Site Plan of the work area showing permanent support structures (piers and abutments); roads; railroad tracks; waterways; overhead and underground utilities; and other information pertinent to erection.

ii. Erection sequence for all members, noting any temporary support conditions, such as holding crane positions, temporary supports, falsework etc. Member reference marks, when reflected on the erection plans, should be the same used on the shop drawings.

iii. Primary member delivery location and orientation.

iv. Maintenance of Traffic during erection operations.

v. Location of each crane for each primary member pick, showing radius and crane support (barges, mats, etc.).

vi. Capacity chart for each crane configuration and boom length used in the work.

vii. Center of gravity locations for primary member.

viii. Rigging weights, capacity and arrangement for primary member picks.

ix. Lifting weight of primary member picks, including all rigging and pre-attached elements.

x. Details of any temporary lifting devices to be bolted or welded to permanent members, including method and time (shop or field) of attachment; capacity; and method, time, and responsibility for removal.

xi. Blocking details for bridge bearings.

5. Jacking and support of existing structures as specified below:

a. Support the structure on temporary supports and brace as necessary to maintain structural stability and prevent lateral movement until completion of the permanent supports. Do not rely on jacks lifting system alone, (e.g. hydraulic system), to support the structure except during the actual jacking operation. Remove all temporary supports upon completion of the jacking procedure.

b. Maintain a maximum differential jacking height of 1/4 inch between any adjacent beam lines.

c. Maintain a maximum differential jacking height of 1 inch between any adjacent abutments or piers.

d. Place jacks and any load plates at least 2 inches from the edges of any concrete substructure seats.

e. Do not field weld temporary members to permanent steel members.

f. Maintain temporary horizontal and vertical clearances according to the contract.

6. When the total load applied to a structure during construction, (new or structure being rehabilitated), exceeds 75 percent of the legal limit, (The Legal Limit is 80,000 lbs. or percentage thereof if posted), the load effects on the structure shall be analyzed based on the operating level calculated by the Load Factor Rating Method as given in the *AASHTO Manual for Bridge Evaluation*.

7. Structures for maintaining traffic in accordance with Item 502.

a. For structures located over or within 14 feet of railroad tracks, submit plans in accordance with 501.05.A.

b. Perform work according to 501.05.B.6.

C. Corrective Work. Unless otherwise noted, before performing corrective work on structure Items 507, 511, 513, 515, 516, 517 and 524, prepare a Corrective Work Plan (CWP). Submit three copies of the CWP to the Engineer for acceptance 30 days, or less at the discretion of the Engineer before construction begins. Have an Ohio Registered Engineer prepare, sign, seal and date each CWP. Obtain City acceptance before beginning corrective work.

Perform all Work in accordance with the accepted CWP. Immediately cease all operations that deviated from the accepted CWP. If a deviation is necessary, furnish the Engineer three copies of a revised CWP. The revised CWP shall be signed, sealed and dated by an Ohio Registered Engineer. Obtain City acceptance of revised CWP prior to performing corrective work.

Perform all corrective work, including the preparation of the CWP and revisions at no expense to the City. The Contractor shall reimburse the City for all CWP review costs of the Designer of Record. The City will consider delays resulting from all corrective work as non-excusable in accordance with 108.06.E.

501.06 Test Reports.

A. Contractor Acceptance of Materials for Item 513. Submit certified test data to the Engineer showing compliance with the requirements of Item 711. Accompany all certified test data with copies of mill shipping notices or invoices showing the quantity and size of material being accepted.

Check this material data and provide a letter of written acceptance. Submit the material data and letter of written acceptance to the Engineer so that the Engineer receives them at least 7 days before final shop inspection Item 513, Levels 1 through 6 or before final shop inspection Item 513, UF Level.

Submit a single copy of this material data for each structure, except where the structure carries railway traffic. Submit one additional copy to each railway company involved.

Additionally for Item 513, Levels 1 through 6 structural steel members, submit one copy of main material, certified test data with a letter documenting the QCFS acceptance to the QA shop inspector before the material passes check point one.

The City will not accept materials for final inspection at the fabrication shop until the Engineer receives the Contractor accepted material data.

B. Fabricator Certification of Materials for Items 516, 517, and 518. Ensure that a letter of certification accompanies the fabricated material shipped to the job site, in a format approved by the Engineer, stating all materials conform to contract requirements. For these materials, the fabricator must retain certified test data, copies of mill shipping notices, or invoices showing the quantity and size of material being accepted. This data shall provide complete traceability to the producing mill and proof of domestic origin, as required by ORC 153.011.

Do not deliver materials to the project without the certification letter.

501.07 Welded Attachments. Prepare and provide a detailed request showing weld size, length, type and location for welding permanent or temporary attachments to main structural members not shown or permitted by contract. Submit request to the Engineer at least 20 days before construction begins. Obtain acceptance before performing work. Perform work according to Item 513.

ITEM 502 STRUCTURES FOR MAINTAINING TRAFFIC

502.01 Description
502.02 Design and Construction
502.03 Maintenance
502.04 Removal
502.05 Basis of Payment

502.01 Description. This work consists of preparing plans, providing, maintaining, and subsequently removing temporary structures.

502.02 Design and Construction. As a minimum, design the temporary structure for a 5-year flood or with 75 percent of the effective waterway opening of the proposed structure. The Contractor is responsible for any damages caused by upstream flooding due to insufficient temporary structure size or the accumulation of debris or sediment in the channel. Provide a clear roadway width of at least 23 feet measured from face to face of guardrails. If the existing structure or approaches or both have sidewalks provide at least one sidewalk at least 5 feet wide with adequate connections to existing walks and in compliance with accessibility standards.

Design the temporary structure according to the AASHTO LRFD Bridge Design Specifications except that the design live loading, HL-93 may be reduced by 25 percent.

Submit working drawings in accordance with 501.05.

Drive piling to sufficient penetration to carry the superimposed loads according to Item 507, but not less than 24 tons per pile. Perform dynamic load testing to determine required blow count if piles are not driven to rock.

If the plans state that the existing superstructure may be used instead of new construction, do not alter it to meet either the above width or strength requirements. Instead, move or dismantle and re-erect with sufficient care to avoid any reduction of capacity. If the superstructure has been restricted by posting to loads less than permitted by statute, move the posting signs to the temporary road, unless the superstructure is strengthened to a legal load capacity. If planning to use the existing superstructure on the temporary road, notify the Engineer at least 3 days before the superstructure is moved to allow the City to establish a detour. Complete the bridge within 48 hours after traffic has been routed over the detour.

502.03 Maintenance. Maintain all portions of the temporary structure in good condition with respect to both safety and smoothness for travel as long as it is needed for maintenance of traffic. Satisfactorily maintain the channel and waterway opening.

502.04 Removal. If the temporary structure is no longer needed, take ownership and remove it from the site according to Item 202.

502.05 Basis of Payment. Payment is full compensation for erection, maintenance, performing dynamic load testing, and subsequent removal of temporary structures.

The City will pay for accepted quantities at the contract price as follows:

Item	Unit	Description
502	Lump Sum	Structure for Maintaining Traffic

ITEM 503 EXCAVATION FOR STRUCTURES

503.01 Description
503.02 Classification
503.03 Cofferdams and Excavation Bracing
503.04 Protection for Excavation
503.05 Footings in Rock
503.06 Approval of Foundations
503.07 Disposal of Excavated Material
503.08 Backfill
503.09 Method of Measurement
503.10 Basis of Payment

503.01 Description. This work consists of designing cofferdams and excavation bracing, and excavating materials not removed under other items of work that must be removed to enable construction of bridges, and other structures. Included in this work are:

A. constructing, maintaining, and subsequently removing cofferdams and excavation bracing;

B. dewatering and backfilling the excavation;

C. protecting the excavation against collapse; and

D. disposing of materials not required or suitable for backfill.

503.02 Classification. Excavation is classified as unclassified excavation, unclassified excavation including rock (or shale), or rock (or shale) excavation.

503.03 Cofferdams and Excavation Bracing. This item includes the preparation of an Engineered Drawing according to 501.05 and the construction, maintenance, and subsequent removal of all cofferdams and excavation bracing. A cofferdam is an enclosure within a water environment constructed to allow dewatering for the purpose of creating a dry work environment. Excavation bracing is that required to safely support the sides of excavations, embankments, adjacent buildings, tracks, or other premises.

Construct cofferdams and excavation bracing such that support members clear the top of the footings by at least 1 foot. If this is not practical, support members shall be structural steel and left it in place. If bracing is to be left in place and the ends would not be visible when the structure is completed, burn off the steel ends flush with the concrete surface. If ends would be visible, form a 6 inch deep recess around the steel embedment and remove the external portion of the embedment to provide at least 3 inches of clearance to the finished concrete face. Completely fill the resulting recess with concrete.

Where water is not encountered, the Contractor may place excavation bracing at the plan dimension of the footing and use it as formwork for footing concrete. Leave this sheeting in place at least to the top of the footing, or properly separate it from the footing concrete so that it may be removed without damaging the concrete.

Where water is encountered, and cofferdams are necessary, construct them practically watertight before excavating below water level. Make provisions outside the footing to drain, collect, and remove water. When placing concrete, keep the excavation dewatered until the concrete is above the prevailing water level. Effectively protect footing concrete from erosion. If using a concrete seal to stop the flow upward from the bottom of a cofferdam, place the seal below the planned footing and consider it as a part of the cofferdam. The City will not pay for a seal unless it is shown on the plans.

Unless otherwise shown in the plans, design and construct cofferdams to accommodate a water elevation 3 feet above the ordinary high water mark shown on the plans. If the actual water elevation exceeds 3 feet above the stated ordinary high water mark, the City will reimburse the Contractor for any resulting damage to the work protected by the cofferdam provided the Contractor has exercised normal due diligence. If the actual water elevation exceeds 3 feet above the ordinary high water mark and causes a delay to the project, the City will grant the Contractor an excusable, non-compensable delay in accordance with 108.06.B.

Establish a monument upstream of all proposed cofferdams to visually monitor the water elevation in the waterway. Maintain the monument throughout the project. Provide a visual mark on the monument that identifies the required high water elevation as defined above. Ensure that the monument can be read from the bank of the waterway. Have this elevation set and certified by an Ohio Registered Surveyor.

Cofferdams may be designed and constructed to accommodate a lower water elevation; however, the City will not reimburse the Contractor for repairs to work damaged nor grant additional time unless the water elevation exceeds 3 feet above the ordinary high water mark shown on the plan.

Submit any request for reimbursement for repair to work damaged or for delay to the Engineer with information substantiating that the water elevation was more than 3 feet above the ordinary high water mark shown on the plans.

503.04 Protection for Excavation. Protect all excavations from caving. Do not disturb the material below the bottom of footings. Perform blasting in a manner that avoids damage to the material supporting the structure vertically or laterally and that avoids subsequent slides that damage the structure, road, or adjacent property. If the material below the bottom of footings not supported by piles is disturbed, remove it and fill the entire space with concrete at no expense to the City. Under footings supported on piles, replace and compact the over-excavated or disturbed material as the Engineer directs. If backfilling is necessary to correct caving or slides, backfill according to 503.08.

Excavation adjacent to railroad tracks are subject to the supervision of the involved railway company. Provide sufficient bracing to ensure the proper support of the roadbed and tracks.

503.05 Footings in Rock. Where rock or shale excavation is a separate pay item, fill the portion of the excavation into rock or shale that is below the top of footing with concrete.

If removing rock or shale as part of Unclassified Excavation and the footing is designed to be keyed into the bedrock, confine the excavation into bedrock for the minimum specified depth of keying within the area bounded by the outer edge of the footing. Fill excavation outside these limits and within and below the keyed depth with concrete.

503.06 Approval of Foundations. Notify the Engineer when the excavation is to be completed to the depth shown on the plans. Do not place footings until the Engineer has approved the subfoundation.

503.07 Disposal of Excavated Material. Dispose of excavated material not needed or not suitable according to 105.16 and 105.17. Use other suitable excavation material for backfill.

503.08 Backfill. Backfill all excavations made under this item with materials conforming to 203.02.R, except behind abutments and below the approach slabs use materials conforming to Item 203 Granular Material Type B.

Place and compact the backfill materials according to 203.06 and 203.07, except as modified by this subsection.

Do not place backfill material against any structural element until the Engineer has approved the element.

In bridge abutment areas compact backfill material to meet the compaction requirements in 203.07. Elsewhere, compact backfill material to 95 percent of the maximum laboratory dry density.

When a test section method is used for compaction acceptance: Use compaction equipment with a total weight or a centrifugal force of least 1 ton. Supply the manufacturers' information to verify this information. Use at least six passes to construct the production areas. Use at least 97 percent of the test section maximum dry density for acceptance of the production areas.

The Contractor does not have to place backfill material around piers that are not within the embankment area or adjacent to a roadway or a railway in thin layers or compact it, but should leave the backfill material in a neat condition with a compensating allowance made for settlement.

Backfill in front of abutments and around piers to the ground lines shown on the plans.

Backfill all structural foundation units as soon as practical after the required conditions of this subsection are met to avoid the ponding of surface water and the accumulation of debris. Simultaneously backfill in front of and behind abutments, piers, wing walls, and retaining walls.

Carefully backfill against waterproofed surfaces to avoid damage to the waterproofing material.

503.09 Method of Measurement. After the requirements of Item 201, Item 202, and Item 203 have been met, the City will measure excavation on a lump sum basis or by the number of cubic yards as follows:

A. Bounded on the bottom. Bounded bottom plane of the footing, crossbeam, or wall.

B. Bounded on the top.

1. In cut sections, by the surface of the remaining ground.
2. In fill sections:
   a. If excavation is performed before embankment is placed, by the surface of the original ground.
   b. If excavation is performed after embankment is placed, by the surface of the embankment.

C. Bounded on the sides.

1. For Unclassified Excavation, 1 foot outside the outer edge of the footing, crossbeam, or wall.
2. For Rock Excavation or Shale Excavation:
   a. If Rock Excavation is included in the Contract, by the outer edge of the footing or wall.
   b. If rock or shale is removed as part of Unclassified Excavation Including Rock and/or Shale:
      (1) Above the minimum specified depth of keying, the same as described in 503.09.C.1.
      (2) For the remainder of the excavation, the same as described in 503.09.C.2.a.

For keys below footings, the City will determine the volume of keys by the number of cubic yards shown on the plans.

The City will measure Cofferdams and Excavation Bracing on a lump sum basis.

503.10 Basis of Payment. If an Item for Cofferdams and Excavation Bracing is not included in the Contract for payment, perform work according to 503.03 and the City will pay for Cofferdams and Excavation Bracing under the contract unit price for excavation.

The elevations shown on the plans for the bottoms of footings are considered as approximate. When excavation below plan elevation for footings is required, the City will pay for the 3 feet immediately below the plan elevation within the lateral limits described in 503.09.C.1 at the unit price bid for the class of excavation.

The City will consider additional excavation to a maximum depth of 1 foot within the lateral limits described in 503.09 as incidental to the lump sum price. Excavation deeper than 1 foot below plan elevation may be provided for as Extra Work, as described in 109.05.

If Cofferdams and Excavation Bracing is a separate pay item, the lump sum price includes any extra cost involved for cofferdams for additional depth up to 3 feet below plan elevation. Excavation deeper than 3 feet below plan elevation and the additional cofferdams necessitated by this excavation may be provided for as Extra Work, as described in 109.05. The Contractor shall provide additional fill material and subsequent excavation to provide the minimum cover over culverts to accommodate heavy earth moving equipment at no expense to the City.

The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
503	Lump Sum	Cofferdams and Excavation Bracing
503	Cubic Yard	Unclassified Excavation
503	Lump Sum	Unclassified Excavation
503	Cubic Yard	Unclassified Excavation Including Rock
503	Cubic Yard	Unclassified Excavation Including Shale
503	Cubic Yard	Unclassified Excavation Including Rock and/or Shale
503	Cubic Yard	Rock Excavation

503	Cubic Yard	Shale Excavation

ITEM 504 SHEET PILING LEFT IN PLACE

504.01 Description
504.02 Materials
504.03 Driving
504.04 Method of Measurement
504.05 Basis of Payment

504.01 Description. This work consists of furnishing and driving steel sheet piling to be left in place, including furnishing and installing any specified anchors or other attachments to structures.

504.02 Materials. Furnish new sheet piling conforming to 711.03. The Contractor may use used sheet piling in good condition that conforms to project requirements provided it is inspected and approved by the Engineer.

504.03 Driving. Drive steel sheet piling to the tip elevation shown on the plans. Thread each sheet pile with adjacent sheets. Use corner piles, junction piles, and interlocking connectors as necessary so that all sheet piles are interlocked.

504.04 Method of Measurement. The City will measure Steel Sheet Piling Left in Place [Minimum Section Modulus of ____ cubic inches per foot] of Wall by measuring the number of square feet in the plane of the face of the sheeting, completed and accepted in place.

504.05 Basis of Payment. The City will pay for accepted quantities at the contract price as follows:

Item	Unit	Description
504	Square Foot	Steel Sheet Piling Left in Place [Minimum Section Modulus of____ cubic inches per foot] of Wall

ITEM 505 PILE DRIVING EQUIPMENT MOBILIZATION

505.01 Description
505.02 Basis of Payment

505.01 Description. This work consists of mobilizing pile driving equipment to and from the project site and, as necessary, to install the required piling.

This work includes the fixed costs that are related to the installation of the required piling.

505.02 Basis of Payment. The City will pay for accepted quantities, after the first service pile is installed, at the contract price as follows:

Item	Unit	Description
505	Lump Sum	Pile Driving Equipment Mobilization

ITEM 506 STATIC LOAD TEST

506.01 Description
506.02 General
506.03 Test Procedure
506.04 Basis of Payment

506.01 Description. This work consists of applying a static load to a driven pile and furnishing instruments and facilities to obtain load-displacement data required to determine the ultimate bearing value of the pile. When subsequent static load tests are specified, the Engineer will determine whether subsequent static load tests are to be performed and the location of all piles to be tested.

506.02 General. Perform the static load test according to ASTM D1143, Procedure A: Quick Test, except as modified below.

Use the hammer selected for driving the test pile to drive all piles represented by the test. If the Contractor finds it necessary to use a different hammer, the Engineer will determine if an additional static load test is necessary.

If using anchor piles to apply the load to the test pile, locate the anchor piles to provide a minimum clear distance of 8 feet from the test pile. The Contractor may use battered piles as anchor piles, provided the horizontal forces in the anchor system are balanced and excessive bending stresses are not induced in the piles. The Contractor may also use bearing piles meeting these requirements as anchor piles. After the test has been completed, remove or cut off at least 1 foot below the bottom of the footing or finished surface of the ground all anchor piles outside the limits of the footing. Cut off anchor piles, other than bearing piles, within the limits of the footing 3 inches above the bottom of the footing. Redrive all bearing piles used as anchor piles that are displaced upward during the application of the test load according to the plan requirements.

For the duration of the test, provide adequate facilities to record load and displacement readings. To avoid column buckling of the pile, ensure that tested piles are substantially vertical and that the load is applied to the pile at a point as near the ground surface as possible.

Provide equipment and loading apparatus to apply a maximum test load of twice the ultimate bearing value. Have a Registered Engineer design the loading apparatus. Determine if piles on the plan order list for cast-in-place reinforced concrete piles have a pile wall thick enough to support the maximum test load of twice the ultimate bearing value. The minimum pile wall thickness to support twice the ultimate bearing value is:

$$t\ (\text{inch}) = \frac{2\ R\ (\text{lb})}{113{,}000\ D\ (\text{inch})}$$

Where:

t = pile wall thickness in inches
R = ultimate bearing value in pounds
D = diameter of pile in inches

If the pile wall thickness for the test pile is less than t, before performing the static load test, either drive a test pile with a thicker pile wall, or fill the pile with concrete and allow the concrete to cure for 5 days. The static load test is unacceptable if the pile fails internally during the test due to improper installation or procedure by the Contractor.

506.03 Test Procedure. Apply the load at least 5 days after placing concrete in the pile or 72 hours after driving both the test pile and the anchor piles.

Use displacement indicators as the primary system to measure axial movement of the test pile top, with a redundant secondary system as described in ASTM D1143.

Apply the test load in increments of approximately one-tenth the ultimate bearing value. Between each load increment, keep the test load constant for 15 minutes. Add load increments until the test load reaches twice the ultimate bearing value or until continuous jacking is required to maintain the test load. Remove the test load in five approximately equal decrements, keeping the test load constant for 15 minutes between decrements. If it is necessary to remove and reapply the load during the test, use the same loading procedure to reapply the test load.

Record test readings taken at 1, 2, 4, 8, and 15 minutes after completing application of each load increment. Record test readings taken at 1 and 15 minutes after each load decrement and after removing all load from the test pile.

Determine the load test ultimate bearing value (Q_f) using the Davisson criteria. First plot the displacement versus load on the pile (Q). Next, draw a line representing the theoretical elastic deformation of the pile, using the following equation.

$$d = \frac{Q\ L}{A\ E}$$

Where:

d = Elastic deformation of pile in inches
Q = Test load in pounds
L = Length of pile in inches
A = cross-sectional area of pile in square inches
E = Elastic modulus of pile in lb/in²
for steel E=29,000,000 lb/in²

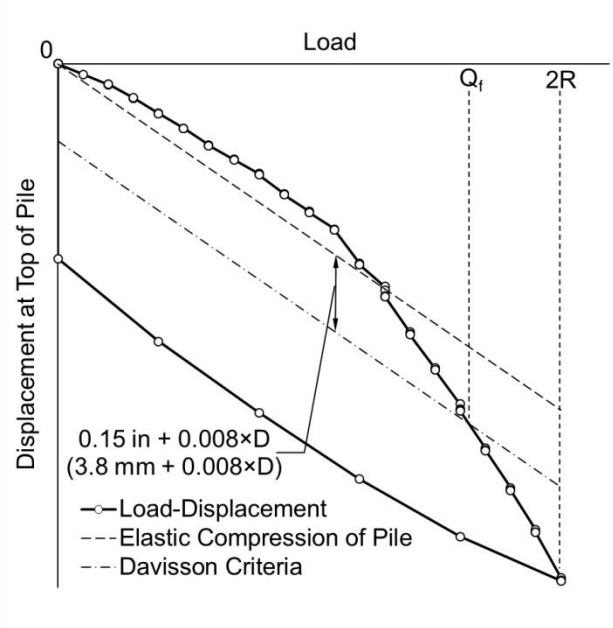
Draw the Davisson criteria line parallel to the theoretical elastic deformation but offset by the following formula:

$$0.15\ \text{inch} + 0.008 \times D$$

Where:

D = Diameter or width of the pile in inches.

The test load ultimate bearing value (Q_f) is the load corresponding to where the Davisson criteria line crosses the load-displacement curve. See the figure below.



Within four days of completing the static load test, submit a report to the Engineer which contains the information required according to ASTM D 1143 and the load displacement graph described above.

506.04 Basis of Payment. If the Contractor subsequently finds it necessary to use a different hammer, the Engineer will determine if an additional static load test is necessary; the Contractor shall complete any such additional test at no additional cost to the City.

The cost of furnishing test piles with thicker pile walls is included under Static Load Test.

The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
506	Lump Sum	Static Load Test
506	Each	Subsequent Static Load Test

ITEM 507 BEARING PILES

507.01 Description
507.02 General
507.03 Materials
507.04 Driving of Piles
507.05 Determination of Required Driving Criteria
507.06 Cast-in-Place Reinforced Concrete Piles
507.07 Steel H-Piles
507.08 Timber Piles
507.09 Splices
507.10 Defective Piles
507.11 Prebored Holes
507.12 Method of Measurement
507.13 Basis of Payment

507.01 Description. This work consists of furnishing and driving bearing piles.

507.02 General. Install piles of the specified type, length, and sizes shown on the plans. Furnish the piles according to the itemized order list shown on the plans. If additional length is needed to obtain bearing, furnish the additional length as determined by the Engineer. The length of the piles given in the order list is not necessarily based on available or practical lengths, but the estimated length from the bottom of each pile to the elevation of the cutoff. The Contractor may increase or decrease the pile lengths to suit the lengths available, to facilitate the method of operation, which may involve providing fresh heading as a result of hammer misalignment or a worn hammer cushion, or to provide lengths determined practical to have delivered to the project site and driven.

507.03 Materials. Furnish materials conforming to the following:

Reinforcing steel 509
Concrete, Class COC 1..... 511
Chemical admixture for concrete, Type F 705.12
Steel H-piles..... 711.03

Steel pile points 711.07
Steel for reinforced concrete piles 711.03
Galvanized steel 711.02
Timber 711.26

Provide a concrete slump from 6 to 8 inches with the use of a superplasticizer.

507.04 Driving of Piles. Drive piles to refusal on bedrock; until obtaining the required ultimate bearing value, which may include a modification for scour, set-up, or negative skin friction; or to the minimum penetration pile tip elevation shown on the plans.

If piles begin to crush, immediately cease driving and repair or replace the pile. The counting of blows will cease until the crushed pile is either repaired or replaced.

For piles subject to scour, notify the Engineer if the required ultimate bearing value is obtained before the pile has penetrated 80 percent of its estimated depth before appreciably overdriving the pile. The Engineer will study the conditions and determine the final penetration, the driving requirements, the use of another pile type, and the use of prebored holes.

All piles raised during the driving of adjacent piles shall be driven down again.

Use a hammer that will achieve the required ultimate bearing value for the pile and large enough to permit a dynamic load test to verify that the ultimate bearing capacity shown on the plans can be achieved.

The ram of an air-operated or diesel hammer shall weigh at least 2700 pounds.

The ram of a drop hammer for permanent piles shall weigh at least 3000 pounds. The height of fall for drop hammers shall not exceed 7 feet. Do not use drop hammers to drive piles that are to be driven to an ultimate bearing value in excess of 70 tons.

When using open ended diesel hammers, provide electronic equipment, such as a saximeter, or equivalent, for the Engineer's use to accurately measure and record the stroke for each unit of length driven.

Attach a gage to closed end diesel hammers, accessible to the Engineer, to monitor the pressure in the bounce chamber. Include a graph with the gage to convert pressure to energy.

Attach an impact energy monitor, or a method to accurately measure the stroke within 2 inches to hydraulic hammers, accessible to the Engineer, to monitor the energy of each blow.

Use securely anchored driving leads and a cap device with sliding jaws to engage the leads to guide the pile and maintain the pile alignment with the stroke of the hammer. Accurately align the travel of the hammer with the axis of the pile.

Cushion the hammer and pile to prevent the impact of driving forces from damaging the top of the pile. Shape the cap and pile top to uniformly distribute the hammer blow to the top surface of the pile.

Do not use a follower unless approved by the Engineer. If the Engineer does approve the use of a follower, account for the increased energy loss when determining the required driving criteria.

If a static load test is required, the Contractor may not drive piles except the test and anchor piles before conducting the test and the required depth of penetration has been determined.

Do not use water jets.

After being driven, cut off the piles at the elevation and angle shown on the plans. Ensure that the actual pile embedment into the concrete is within 2 inches of the embedment shown in the plans.

Maintain a minimum radius of 15 feet between simultaneous work of placing concrete and driving piles. If concrete is placed within the 15-foot radius, suspend driving operations until the concrete has cured for 5 days.

507.05 Determination of Required Driving Criteria. Determine the required driving criteria to achieve the ultimate bearing value of a driven pile as if the pile was a single isolated pile using the results of dynamic pile testing as specified in Item 523. The driving criteria may consist of a minimum blow count with a minimum hammer stroke, a minimum depth of penetration, or both.

To determine the minimum blow count for battered piles, divide the minimum blow count for vertical piles with the same ultimate bearing value by an efficiency factor (D) that is less than one. This will result in an increased minimum blow count for the battered piles. Compute the efficiency factor (D) as follows:

$$D = \frac{1 - (U \times G)}{(1+G^2)^{0.5}}$$

Where:

U = Coefficient of friction
use 0.05 for double-acting air operated or diesel hammers,
use 0.1 for single-acting air operated or diesel hammers, and
use 0.2 for drop hammers.

G = Amount of batter (H/V; 1/3, 1/4, etc.)

507.06 Cast-in-Place Reinforced Concrete Piles. Provide cast-in-place reinforced concrete piles conforming to one or more of the types described below. Measure the pile diameter as follows:

A. Plain cylindrical casing, the outside diameter.

B. Cylindrical casings with vertical fluting, the diameter of a circle circumscribing the outermost points or ridges.

C. Cylindrical casing with circumferential corrugations, the average of the outside diameters measured at the bottom and top of the corrugations or continuously welded helical corrugations with diameters measured at tops of the corrugations.

D. Tapered piles, the top diameter as determined in 507.06.A, 507.06.B, or 507.06.C, but the pile tip diameter shall not be less than 8 inches.

Ensure that the pile casings are watertight after being driven. If furnished, shoes or points shall not project more than 1/4 inch outside the vertical surface of the casing.

For plain cylindrical casings, the minimum pile wall thickness, t, is the greater of either 0.250 inches or the thickness determined using the following formula:

$$t\ (\text{inches}) = \frac{R\ (\text{lb})}{900{,}000}$$

Where:

R= Ultimate bearing value in pounds

For fluted piles, the minimum pile wall thickness shall be t/1.4.

For cast-in-place piles containing reinforcing steel, place reinforcing steel as stated in the second and third paragraph of 524.09 and place concrete according to 524.11.

After installation, cover the tops of driven casings until the concrete is placed. Before placing concrete, remove accumulated water or other foreign matter in a driven casing. Place concrete for cast-in-place piles using methods that prevent voids, however, do not vibrate the concrete.

507.07 Steel H-Piles. Steel H-piles shall consist of structural steel shapes of the kind and size specified.

The Engineer may allow installation of steel piles of the specified type, which the Contractor has from previous projects or stock, if the Contractor furnishes mill certifications and the pile sections are identified with the material specification number, grade, and heat number. This identification may be in the form of information painted on the steel piles or a tag physically attached to the steel.

507.08 Timber Piles. Provide timber piles of sufficient length to remove broomed or split portions caused by driving. Symmetrically trim piles right truncated cone at the tip. If steel shoes or points are specified, carefully shape the tip of the pile so that the steel shoe or point fits snugly and symmetrically.

Handle and store timber piles to prevent warping.

If specified, provide creosoted piles conforming to 712.06.

507.09 Splices. To the fullest extent practical, avoid splicing steel casings and structural shapes. Splice pile casings and structural shapes either before or after driving a segment. If spliced after driving a segment, splice the piles at least 3 feet above the ground and inspect the splice while the pile is driven a minimum of 150 blows.

Align segments to make the axis of all segments common.

Use full penetration butt welds to splice steel pile casings according to AWS D1.1 and structural shapes according to AWS D1.5. Non-destructive testing is not required.

Do not splice timber piles.

Pile Points. When specified in the plans, select a product from the City's approved list. Weld the pile points to the pile according to AWS D1.5 or the manufacturer's written welding procedure supplied to the Engineer before the welding is performed. Submit a notarized copy of the mill test report to the Engineer.

507.10 Defective Piles. Install the piles, so that after driving, they are within 12 inches from the location shown on the plans for piles capped below final grade, and within 3.0 inches from the plan location for pile caps above the ground surface. Piles not meeting these location tolerances are defective piles.

Pipe piles are defective if not water tight or if damage reduces the cross-sectional area by more than 20 percent. Provide the Engineer with a light that allows inspection of the entire length of the interior of a driven casing.

Replace, repair, or drive a substitute pile beside the defective pile. The location tolerance for underground piles does not apply to substitute piles beside defective underground piles. The off-location limits do apply to the substitute pile that project above the ground. If a defective pile is removed, fill the hole remaining in the ground with sand. Cut off a defective pile left in place under a footing 3 inches above the elevation of the bottom of the footing. Cut off a defective pile left in place but not under a footing at least 1 foot below ground level. Fill defective pipe piles left in place with concrete.

When the outside rows of bearing piles are not located within tolerances specified above, increase the size of the footing to provide a minimum distance between the pile and footing edge of at least 75 percent of that shown on the plans.

507.11 Prebored Holes. Locate prebored holes as shown on the plans. Provide augured hole diameters:

A. For round piles, from 2 inches less to 4 inches more than the pile diameter.

B. For steel H-piles, from 6 inches less to 2 inches more than the pile's diagonal dimension but shall be such as to produce satisfactory pile driving results.

Backfill voids between the pile and the prebored hole with a granular material satisfactory to the Engineer.

507.12 Method of Measurement. The City will measure piles driven by the number of feet. The City will determine the sum as the lengths of all non-defective piles measured along the axis of each pile from the bottom of each pile to the elevation of cutoff. Unless a separate pay item is specified in the Contract, the City will include Steel Points or Shoes in the measured length of driven piles. If a separate pay item is specified in the Contract, the City will measure Steel Points or Shoes by the number of each.

The City will measure piles furnished by the number of feet of plan specified order length plus any additional order length specified by the Engineer. The Engineer will include the length of undriven piles as furnished, but the Contractor will not receive additional compensation for hauling the piles off the project.

For plan specified prebored holes, the City will measure Prebored Holes by the number of feet of prebored hole lengths for non-defective piles measured from the surface of ground at the time of boring to the bottom of the hole. The City will not measure preboring to facilitate the pile driving operation.

507.13 Basis of Payment. When the Contractor elects to prebore to facilitate the pile driving operation, include the cost for preboring in the unit price bid for piles driven.

The City will consider the cost of furnishing and installing the reinforcing steel to be included in the unit price bid for piles driven.

The City will not pay for any splices due to the Contractor furnishing pile lengths shorter than plan order lengths. The City will not pay for increased pile lengths made by the Contractor unless the Engineer determines that the additional lengths are needed to achieve bearing. If additional penetration is necessary in order to achieve the required bearing, the City will pay for required splices at a negotiated price.

The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
507	Foot	Steel Piles HP____×____, Furnished
507	Foot	Steel Piles HP____×____, Driven
507	Foot	___ inch Cast-In-Place, Reinforced Concrete Piles, Furnished
507	Foot	___ inch Cast-In-Place, Reinforced Concrete Piles, Driven
507	Foot	Timber Piles, Creosoted
507	Foot	Timber Piles, Untreated
507	Foot	Prebored Holes
507	Each	Steel Points or Shoes

ITEM 508 FALSEWORK AND FORMS

508.01 Description
508.02 Falsework
508.03 Forms
508.04 Oiling Forms
508.05 Basis of Payment

508.01 Description. This work consist of designing and building of falsework and forms for the purpose of holding concrete in place until it has set up.

508.02 Falsework. Provide substantial and rigid falsework that does not unduly obstruct any waterway, highway, or railway. Arrange intermediate supports in the completed structure to produce the camber necessary to conform to the plan profile of the roadway.

Do not allow the maximum deflection in the longitudinal falsework members at the edges of the concrete deck to exceed 1/2 inch or the amount obtained by the following formula, whichever is greater.

$$d = \frac{S + 100}{1000}$$

Where:

d = the maximum deflection in inches
S = the distance between supports in inches

For transverse falsework members, and for longitudinal falsework members other than those near the edges of the deck, increase the permissible deflection obtained from the above formula by 75 percent.

To compensate for falsework deflection, build camber into the falsework. In addition to falsework defection, build the following amounts of camber into the falsework to compensate for slab deflection after falsework is released:

A. Equal to 1/800 of the span for continuous spans.

B. Equal to 0.000018 S^3 for simple spans, where S is the length of the slab span in feet for camber expressed in inches.

Provide camber to conform to the profile grade.

If the falsework does not rest in rock, shale, or other firm foundation material, support falsework on piling driven to sufficient penetration to carry the superimposed loads according to Item 507, but not less than 16 tons per pile. Perform dynamic load testing to determine required blow count if piles are not driven to rock. Do not use expansion anchors to support falsework on piers or abutments. Use double hardwood wedges as necessary to facilitate vertical adjustment.

Remove and replace any part of the structure made unsatisfactory by incorrect camber, settlement or form deformation.

Construct falsework for arches so it may be released gradually.

Remove falsework only after the concrete conforms to 511.14 and before final acceptance of the structure. Cut off or pull falsework piling. Cut off piles to at least the slope line, riprap line, or stream bed.

Locate the lower contact point of overhang falsework within 8 inches of the top of the rolled beam or steel girders bottom flange.

Submit falsework plans for cast-in-place concrete slab superstructures according to 501.05.

If a thickened edge is shown on the plans, the Contractor may develop the edge by sloping the bottom of the slab for a minimum of 9 feet from the edge, instead of the section shown.

Do not place spandrel walls, decks of arches, sidewalks and curbs, or any superimposed concrete to be completed after constructing the main supporting member or the deck until the falsework for the main supporting member has been removed or released.

For continuous concrete slab or beam superstructures, do not place concrete on a span until the falsework and forms are complete for the adjacent spans. Do not release or remove falsework from a span until the concrete in adjacent spans has been placed a sufficient length of time to meet all requirements for the removal of falsework as set forth in 511.14. Inserts cast into prestressed members for the purposes of falsework support shall be galvanized according to 711.02 and shall be shown in the shop drawings according to 515.06.

508.03 Forms. Place all concrete in proper forms. Do not use unprotected sides of the excavation, instead of forms, unless as specified in 503.04 for rock or shale excavation. For dry excavation specified in 503.03, the Contractor may use the sheeting as forms for footings.

Construct substantial, unyielding, and mortar tight forms, designed to produce a finished concrete conforming to the proper dimensions and contours. Make forms for exposed surfaces of approved material requiring a minimum number of joints or of dressed lumber of uniform thickness using form liner approved by the Engineer. Use forms and form liners to reduce the joints showing on the finished surface to a minimum. Arrange joints to coincide with rustication grooves shown on the plans. Properly brace or tie forms together using approved form ties that do not allow metal within 2 inches of an exposed surface of the finished structure after the forms are removed. For ties in the region of exposed surfaces, use an approved insert. Remove all forms and do not allow material, except reinforcing supports specified in 509.08, to remain in the concrete.

In forming pier, intermediate, or end diaphragms for prestressed or post-tensioned concrete members, do not damage reinforcing steel, strands, or precast concrete in the placement of post installed anchors in these members. Properly brace diaphragm forms externally or use approved form tie inserts cast into these members.

For concrete decks separated by an open median or temporarily separated by a closure section, construct falsework and forms for each deck or section of deck independent of the adjacent structure or remaining superstructure.

Immediately before placing concrete, provide temporary openings at the base of column and wall forms and in the bottom of all narrow, deep members where necessary to facilitate cleaning or inspection.

Provide a 3/4-inch bevel on all exposed edges using a triangular strip built into the forms.

If rustication is used, fasten molding that is surfaced on all sides to the forms in such a manner that the molding remains in the concrete when the forms are removed. Do not remove this molding until the concrete has set sufficiently to prevent damage to the edges of the concrete.

If weep holes through abutments or retaining walls are shown on the plans, form weep holes to obtain a smooth circular opening between 3 and 4 inches and a straight gradient of 0.08 through the wall.

508.04 Oiling Forms. Before placing reinforcing steel, coat the inside of forms with non-staining mineral oil or other approved material.

508.05 Basis of Payment. The City will not separately pay for falsework and forms. The cost of this work is included for payment in the price bid for the item for which falsework and forms are used.

The City will not pay for removal and replacement of any part of the structure made unsatisfactory by settlement or form deformation.

The City will not pay for dynamic load testing required in 508.02 to determine blow count if piles are not driven to rock.

ITEM 509 REINFORCING STEEL

509.01 Description
509.02 Materials
509.03 Care of Material

509.04 Method of Placing
509.05 Bending
509.06 Approval of Placing
509.07 Splicing
509.08 Supports
509.09 Epoxy Coated Reinforcing Steel
509.10 Method of Measurement
509.11 Basis of Payment

509.01 Description. This work consists of furnishing and placing supports, mechanical connectors, tie wires, and reinforcing steel of the quality, type, size, and quantity designated, including steel dowels.

509.02 Materials. Furnish materials conforming to:

Epoxy coated reinforcing steel 709.00
Reinforcing steel,
deformed bars 709.01, 709.03, 709.05
Spiral reinforcing steel ..... 709.01 or 709.08
Bar mats and wire fabric 709.09, 709.10, 709.12
Plastic supports..... 709.15

For metal bar supports used at or near the surface of the concrete, furnish either galvanized steel, stainless steel, epoxy coated steel or plastic coated steel.

Provide sufficient additional reinforcing steel to replace reinforcing steel removed by the City for sampling. Replace random samples in the structures with additional steel, spliced according to 509.07.

When providing reinforcing steel for spiral cages, galvanized steel conforming to ASTM A767, Class 1, may be provided only for the spiral reinforcing steel in lieu of epoxy coated reinforcing steel. The galvanized coated reinforcing steel will meet all other requirements of Item 509. Where a sample splice is needed use the lap length requirements for epoxy coated. The Galvanized coating will be applied after the reinforcing has been fabricated. If the galvanized surface becomes damaged during handling in the field, repairs will conform to ASTM A780. Use bar supports and tie wires which are plastic coated or epoxy coated. Only suppliers certified under ODOT Supplement 1068 may provide this reinforcing.

509.03 Care of Material. Upon delivery to the project and before use, stack reinforcing steel off the ground and keep it free from dirt, oil, grease, or avoidable rust. Before placing in the concrete, ensure the reinforcing steel is clean and free of loose rust.

509.04 Method of Placing. Place reinforcing steel in the positions shown on the plans, and firmly secure the steel during the placing and setting of concrete. Tie bars in the superstructure at all intersections, except tie bars at alternate intersections where bar spacing is less than 1 foot in any direction. The Contractor may place up to 25 percent of the upper longitudinal bars in a bridge deck slab beneath the upper transverse bars to support the top mat. Do not drive or force reinforcing steel into concrete after it is initially set.

Welding on reinforcing is prohibited, except as permitted by 709.10 and 709.12. The Engineer will allow the Contractor to fabricate reinforcing bar cages for prestressed beams if fabrication is done in a manner satisfactory to the City.

Install reinforcing steel with at least the following clearances from the concrete surface:

A. 2 1/2 inches [-0 inch, +0.5 inch] to the top of sidewalks.

B. 3 inches [-0 inch, +0.5 inch] at the faces of footings placed against rock or earth.

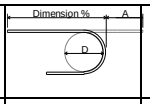
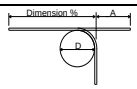
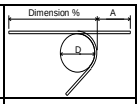
C. 1 1/2 inches [-0 inch, +0.25 inch] to the bottom of a cast-in-place deck slab.

D. 3 inches [±0.25 in] between the reinforcing steel and the top surfaces of cast-in-place concrete deck slabs.

E. 2 inches [-0 inch, +0.5 inch] at all other surfaces.

509.05 Bending. Bend reinforcing steel to the dimensions shown on the plans and in Table 509.05-1. Reject reinforcing steel showing transverse cracks.

TABLE 509.05-1 STANDARD BENDS

	Bar								
	Nominal Dimensions			**180° Bend**		**90° Bend**		**135° Bend**	
Bar	**Diameter**	**Area**	**Weight**	**D**	**A**	**D**	**A**	**D**	**A**
Size	**in**	**in²**	**lb/ft**	**in**	**in**	**in**	**in**	**in**	**in**
3	0.375	0.11	0.376	2 1/4	5	2 1/4	5	1 1/2	4
4	0.500	0.20	0.668	3	6	3	7	2	4 1/2
5	0.625	0.31	1.043	3 3/4	7	3 3/4	8 1/2	2 1/2	5 1/2
6	0.750	0.44	1.502	41/2	8	4 1/2	10		
7	0.875	0.60	2.044	5 1/4	10	5 1/4	12		
8	1.000	0.79	2.670	6	11	6	131/2		
9	1.128	1.00	3.400	9 1/2	15	9 1/2	15 1/2		
10	1.270	1.27	4.303	10 3/4	17	10 3/4	18		
11	1.410	1.56	5.313	12	19	12	20		
14	1.693	2.25	7.65	18 1/4	27	18 1/4	25		
18	2.257	4.00	13.60	24	36	24	33		
Tolerances: For diameter of bends, "D", the tolerance may be plus or minus the diameter of the bar. Standard fabricating tolerances shall be in accordance with the CRSI Manual of Standard Practice. No weight allowances will be made for tolerances.									

509.06 Approval of Placing. Before placing concrete, obtain the Engineer's approval of reinforcing steel in place.

509.07 Splicing. Splice reinforcement only as specified or determined by the Engineer. Splice spiral reinforcement by lapping 1 1/2 turns. Do not replace spiral reinforcement removed for a material sample if the sample is from the end of the spiral and less than or equal to 30 inches long.

Mechanical connectors shall be capable of developing 125 percent of the yield strength of the connected bars. For threaded connections, do not reduce the nominal area of the bars shown in the plans without increasing the grade of reinforcing bar shown in the plans. The total slip of the bar within the splice sleeve of the connector after loading in tension to 30.0 ksi and relaxing to 3.0 ksi shall not exceed the following measured displacements between gage points clear of the splice sleeve:

A. For bar sizes up to No. 14: 0.01 in.

B. For No. 18 bars: 0.03 in.

Splice Nos. 14 and 18 reinforcing steel bars with mechanical connectors.

The City will not permit lap splices for these size bars.

Splice Nos. 14 and 18 reinforcing steel bars with mechanical connectors. The City will not permit lap splices for these size bars.

Splice additional steel used to replace random samples as follows:

TABLE 509.07-1

Bar Size	Lap Length (inches)	
	Uncoated	**Epoxy Coated**
4	22	27
5	29	35
6	34	41
7	43	52
8	57	69
9	72	87
10	92	111
11	113	137

509.08 Supports. Use precast mortar blocks, metal supports with plastic coated feet, or plastic supports of adequate strength, of the proper depth, and in sufficient number to support reinforcing steel. Space supports for reinforcing steel no more than 4 feet apart transversely and longitudinally. Metal and plastic supports shall have a shape that is easily enveloped by the concrete.

Mortar blocks may only be used to support the lower mat of reinforcing steel in concrete that is cast directly against bedrock or soil.

509.09 Epoxy Coated Reinforcing Steel. Use plastic coated or epoxy coated bar supports and tie wires to protect the epoxy coating from physical damage, as specified in 709.00, during placement and to prevent electrical coupling between mats. Carefully handle and install bars to perform minimal patching at the job site. Repair physical damage to the epoxy coating with a patching material all damaged coating areas greater than 1/4-inch square or 1/4-inch diameter; approximately 1/8-inch square or 1/8-inch diameter if the opening is within 1/4-inch of an equal or larger opening; or, a length of 6 inches regardless of area. Coating damage in cases where the damaged area is less than specified above, need not be repaired. Use patching material of the same composition and quality as the original coating. Prepare the surface to a near white metal.

If repair is required, clean and repair the damaged areas and allow adequate cure time before placing concrete. The Engineer will approve the installation once patching has been done as outlined above.

509.10 Method of Measurement. The City will measure Epoxy Coated Reinforcing Steel by the number of pounds shown on the plans. Additional measurements or calculations are not required.

If the Contractor believes the pay weight, as shown on the plans, is in error, the Contractor is responsible to prove this discrepancy by recalculating the total weight for the reference number involved. The Contractor shall submit its figures to the Engineer for review and approval. The number of pounds of reinforcing steel shall be the actual number of pounds of the various sizes incorporated in the concrete as shown on the plans, completed and accepted.

If the weight of the reinforcing steel is recalculated, determine the number of pounds from the number, length, and weight of the bars as shown on the steel list of the plans, based on the weight per foot shown in the Table 509.05-1 with deductions for bars not used, and addition for extra bars used as directed by the Engineer**.**

509.11 Basis of Payment. The City will not include the supports, mechanical connectors, and tie wires in the calculated weights but will consider them incidental to the price bid.

The City will pay for accepted quantities at the contract price as follows:

Item	Unit	Description
509	Pounds	Epoxy Coated Reinforcing

ITEM 510 DOWEL HOLES

510.01 Description
510.02 Materials
510.03 Drilling of Holes
510.04 Placement
510.05 Curing and Loading
510.06 Basis of Payment

510.01 Description. This work consists of drilling holes into concrete or masonry, and furnishing and placing grout into the holes. The furnishing and placing of steel for dowels is included in Item 509.

510.02 Materials. Cement grout consists of one part of hydraulic cement conforming to Item 701 and three parts sand conforming to 703.03, by volume, and water.

Furnish nonshrink, nonmetallic grout conforming to 705.20.

510.03 Drilling of Holes. Drill holes at the location and the depth shown on the plans without spalling the concrete.

Drill holes for cement grout at least 1/2 inch larger in diameter than the dowel bar. Drill holes diameters for nonshrink, nonmetallic grout at least 1/16 inch larger in diameter than the dowel bar. Drill hole for encapsulated type nonshrink, nonmetallic grout as recommended by the manufacturer.

Instead of drilling holes, the Contractor may install formed holes with laitance removed.

510.04 Placement. Do not install grout if the temperature of the concrete into which the grout is being placed is below 40 °F. Force dowel bars into the holes, to the specified depth, spreading the grout around the bar and solidly filling the hole.

Before installing cement grout and dowels, saturate cement grout dowel holes with water then blow out all excess water. Place enough cement grout to completely fill the holes during dowel installation. If cement grout does not completely fill the hole, remove the dowel, pour additional grout into the hole, and reinstall the dowel.

Before installing nonshrink, nonmetallic grout and dowel, clean and dry the grout holes. Immediately after mixing, place a sufficient amount of nonshrink, nonmetallic grout to provide complete coverage around the dowel to ensure anchorage. If nonshrink, nonmetallic grout does not completely fill the hole, pour additional grout in until the hole is filled flush.

Obtain the correct protrusion of the anchors or dowels, and hold dowels in the plan position within the holes until the grout has initially hardened.

If horizontal holes are specified, provide a means of retaining the grout in the hole flush with the vertical face and remove this material after the grout has hardened. Do not use material for retaining the grout that bonds to the grout.

510.05 Curing and Loading. Before applying any stresses to dowels, cure nonshrink, nonmetallic grout as follows:

Daily Minimum Ambient Temperature	Minimum Curing Time
33 to 50 °F	3 hours
51 to 68 °F	1 1/2 hours
above 68 °F	1 hour

510.06 Basis of Payment. The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
510	Each	Dowel holes with cement grout
510	Each	Dowel holes with nonshrink, nonmetallic grout

ITEM 511 CONCRETE FOR STRUCTURES

511.01 Description
511.02 Materials
511.03 Concrete
511.04 Quality Control Requirements
511.05 Mixing of Concrete
511.06 Slump
511.07 Placing Concrete
511.08 Slipform Construction of Bridge Railing
511.09 Construction Joints
511.10 Work Stoppage
511.11 Depositing Concrete under Water
511.12 Depositing and Curing Concrete during Cold Weather
511.13 Removal of Forms
511.14 Curing and Loading
511.15 Surface Finish
511.16 Roadway Finish
511.17 Bridge Deck Grooving
511.18 Sidewalk Finish
511.19 Joints, Cracks, Scaling and Spalls
511.20 Compressive Strength
511.21 Air Content
511.22 Not Used
511.23 Method of Measurement
511.24 Basis of Payment

511.01 Description. This work consists of providing falsework and forming, furnishing, placing, consolidating, finishing, and curing portland cement concrete. This work also includes diamond saw cutting longitudinal grooves into the surface of superstructure concrete. Construct falsework and forms as required in Item 508.

511.02 Materials. Furnish materials conforming to 499.02, except as modified below.

Use the same kind and color of aggregate for all concrete above the ground line in a given substructure unit and for all concrete in a given superstructure.

Use high molecular weight methacrylate resin sealer conforming to 705.15.

Use curing materials conforming to 705.05; 705.06 (white opaque); or 705.07; Type 1 or 1D.

Use 1/4-inch gray sponge joint filler conforming to 711.28, or use preformed filler conforming to 705.03.

Use preformed elastomeric compression joint seals conforming to 705.11.

511.03 Concrete. Provide concrete for structures according to 499.03, using Class COC 1, COC 2, COC 3, or COC 4 as specified in the Contract.

At least 10 days before placing concrete, submit, in writing, the City accepted Job Mix Formula (JMF) to the Engineer. The Engineer will review the mix design for conformance to contract requirements; otherwise the mix design is for the Engineer's information.

511.04 Quality Control Requirements.

A. General. The Engineer will make acceptance test cylinders as follows:

Structures of 20-foot span or less.	At least one set of test cylinders for each 50 cubic yards of concrete.
Structures over 20-foot span.	A set of test cylinders from each 200 cubic yards of concrete, or fraction thereof that is incorporated into the work each day.

With any Item 511 concrete bid item provide and maintain a Concrete Cylinder Curing Box (CCCB) capable of holding at least 12 4 × 8 inch cylinders at a temperature of 60 to 80 °F degrees no matter what the ambient temperature. The box will have a sealed lid. If the project has numerous Item 511 concrete bid items CCCB are not required for each bid item. Locate the CCCB at a site that is convenient to the concrete work and will

eliminate handling damage to both the Contractor cylinders and the City Cylinders. Move the CCCB as needed during the project when the distance from the concrete work increases the possibility of cylinder handling damage.

B. Mass Concrete Requirements. For concrete components with a minimum dimension of 5-ft or greater, develop a concrete mix design COC 4 for mass concrete according to 499.03. Develop a Thermal Control Plan (TCP) to control placement of the mass concrete so that the highest maximum internal temperature of the placed concrete is not greater than 160^0 F and the maximum differential concrete temperature does not exceed 36^0 F over 28 days from time of placement.

For drilled shafts with a dimension of 7-ft diameter or greater, develop a concrete mix design COC 4 for mass concrete, COC 4 according to 499.03. Develop a TCP to control placement of the mass concrete so that the highest maximum internal temperature of the placed concrete is not greater than 160ºF.

Submit the TCP to the Engineer for acceptance at least 10 calendar days prior to placement along with the approved JMF (s).

As a minimum, the TCP shall include the following information:

1. Duration and method of curing.

2. Procedures to control concrete temperature at the time of placement. The mix shall contain no frozen pieces of ice after blending and mixing components.

3. Methods and equipment used for controlling temperature differentials.

4. Temperature sensor types, locations and installation details. As a minimum, concrete temperatures shall be monitored at the calculated hottest location, on at least 2 outer faces, 2 corners, and top surfaces.

5. Temperature monitoring and recording system; operation plan; recording and reporting plan with example output; and a remedial action plan.

6. Criteria for form removal to control the maximum temperature differential.

As an alternative to the maximum differential concrete temperature specified above, the Contractor may propose maximum differential temperature limits based on strength gain with time. The TCP for the alternative proposal shall include the methods used to determine the temperature and supporting data and design to support the accuracy of the method chosen. Provide complete calculations and basis for increasing the maximum differential temperature specification. The TCP for the alternative proposal shall also provide the Engineer with tables that define ambient temperatures for acceptable concrete placement, the required temperature of the concrete for the ambient air temperature, the maximum predicted concrete temperature, the maximum predicted differential temperature, the time for removal of forms, the allowable air temperature for form removal, and the predicted maximum and differential temperature from placement to age of 28 days. The City will consider all cracking of a mass concrete placement where the differential temperature exceeded 36 ºF the responsibility of the Contractor.

Upon the Engineer's acceptance of the TCP, continuously monitor all temperature sensors over the required age of the concrete. If the maximum limit or differential temperature limits are exceeded at any time, immediately take action to retard and reduce the out-of-specification temperatures. If a mass concrete placement temperature exceeds the specification limits of the currently accepted TCP, re-engineer, revise and resubmit the TCP. Do not place additional mass concrete until the revised TCP is accepted.

The City will consider in-place mass concrete that exceeds the temperature limits or that cracked, as defective and resulting delays as non-excusable. Determine the extent and effect of the damage and submit a proposed repair plan to the Engineer to return the concrete to acceptable quality. The City will determine if the proposed repair methods are acceptable or if removal is required.

511.05 Mixing of Concrete. Mix concrete according to 499.08.

511.06 Slump. Within the slump ranges specified in 499.03, provide a slump that produces concrete that is workable in the required position, flows around reinforcing steel, and coats individual particles of coarse aggregate with mortar containing the proportionate amount of sand.

511.07 Placing Concrete. Submit to the Engineer a description of proposed placing procedures and notify the Engineer at least 24 hours in advance of placing concrete.

Place and finish concrete to the lines and grades shown in the plans.

Unless otherwise noted, the proposed beam seat elevations shown in the plans for prestressed beam superstructures are based on the design midspan camber for prestressed beams which are 30 days old (D_{30}). Adjust each beam seat elevation using measured midspan camber data provided by the fabricator if available. In the absence of measured midspan camber, adjust each beam seat elevation using the following:

$$\Delta Y = D_t - D_{30} \geq 0$$

Where:

ΔY = Distance that each seat elevation shall be lowered from plan elevation to account for midspan camber growth rounded to the nearest 1/8-inch

D_t = $(1 + \psi)\, D_0$

D_{30} = Design Midspan Camber at Day 30 provided in the plans; inch

D_0 = Design Midspan Camber at Day 0 provided in the plans; inch

ψ = $1.97\, K_S\, K_F\, K_{TD}$

K_S = $1.45 - 0.13\ (V/S) \geq 1.0$

V/S = Ratio of the prestressed concrete member's volume-to-surface area exposed to the atmosphere. For each of the standard I-beam sections, this ratio is provided on PSID-1-13; inch

K_F = $5/(1 + f'_{ci})$

f'_{ci} = Compressive strength of prestressed concrete at release provided in the plans; ksi

K_{TD} = $t/(61 - 4\ f'_{ci} + t)$

t = Age of prestressed concrete measured between release of prestressing force (eg. 0.75 days) and time of deck placement; days

Provide the Engineer with revised plan sheets and Design Camber calculations or measured camber data signed, sealed and dated by an Ohio Registered Professional Engineer at least 7 days prior to constructing the beam seats. The revised plan sheets shall include the measured camber data (if available), Design Camber (D_t) and beam age (t) assumed for establishing the revised elevations. Provide haunch reinforcement for prestressed I-beam members according to the ODOT Bridge Design Manual, Figure 302.5.2.3-2 as necessary to extend the beam's composite reinforcement at least two inches into the deck thickness. All revisions resulting from adjusted beam seat elevations shall be clearly marked as revised. Do not begin work until the Engineer approves the revised plan.

Provide coverage over or around reinforcing steel as described in 509.04.

Conform to the following tolerances from plan dimensions:

TABLE 511.07-1 PLACEMENT TOLERANCES

Deviation from plumb for exposed surfaces	± ¾ inch
Vertical alignment (Deviation from a line parallel to the grade line)	± ½ inch in 20 feet Max ±1 inch
Longitudinal alignment (Deviation from a line parallel to the centerline or baseline)	±½ inch in 20 feet Max ±1 inch
Width dimensions of walls for exposed surfaces	±½ inch
Bridge Slab thickness	±¼ inch
Elevations of beam seats	±1/8 inch
Slope, Vertical Deviation from Plane	±0.2%
Slope, Horizontal Deviation from Plane	±0.4%

Until discharged in the work, ensure that the temperature of all concrete does not exceed 95 °F.

When placing superstructure and approach slab concrete, assure the ambient air temperature is 85 °F or less and not predicted to go above 85 °F during the concrete placement; and evaporation rates, determined according to Figure 1 in ACI 308, do not exceed 0.1 lbs/ft^2/hour.

Determine and document the ambient air temperature, concrete temperature, deck surface temperature, relative humidity, and wind velocity, subject to verification by the Engineer. Measure data required in Figure 1 from within 10 feet of the area where the superstructure concrete is placed.

Figure 1 does not apply to substructure items and formed parapets. Figure 1 applies to slip-formed parapets and approach slabs.

To meet favorable atmospheric conditions, may require the Contractor to place concrete at night. At least 24 hours before placing concrete at night, submit a lighting plan for the work area to the Engineer. Obtain the Engineer's approval of the lighting plan before placing the concrete. Direct lights so that approaching traffic is not affected or distracted.

Before placing a concrete deck on continuous steel beams or girders, complete all of the main beam or girder splices at least two piers beyond the pier or piers supporting the concrete.

Before placing concrete for backwalls above the approach slab seat with steel expansion joints, backfill the abutments to within 2-feet of the bridge seat elevation, erect structural steel or prestressed concrete beams and place superstructure concrete in the adjacent span. Use the steel expansion joint as a template for the top of the backwall. If temporary bolts are used to support the backwall portion of an expansion device during the placing of the backwall concrete, remove the bolts after the concrete has taken its initial set and before a change in temperature causes superstructure movement sufficient to damage the backwall.

Before placing concrete, assure the Engineer of an adequate and uniform source of supply of concrete to allow proper placing and finishing, and of the availability of coverings to protect the concrete from rain.

Do not add or apply water to the concrete after it has left the truck and before applying curing materials according to 511.14.

Before placing concrete, thoroughly clean all forms and structural steel that contact the concrete and ensure that the space to be occupied by the concrete is free of laitance, silt, dirt, shavings, sawdust, loose and built-up rust, and other debris.

Deposit concrete using methods that ensure reinforcing steel is completely enveloped in concrete mortar and that allow inspection of concrete enveloping the reinforcing steel. Use a method or device to convey the concrete from the mixer to the work that prevents coarse aggregate separating from the mortar. If depositing concrete in shallow members, such as slabs, place it with as short a vertical drop as possible. Place the concrete over

a section to maintain a practically horizontal surface. If using a chute, slope the chute to allow concrete to flow without segregation. Place concrete as near as possible to its final position.

Drop concrete into the forms with a free-fall distance of 5 feet or less. As necessary, use drop chutes to limit the free fall to 5 feet and to ensure the delivery ends as vertical as possible.

For concrete delivered to the point of placement by means of pumping equipment, ensure the air content at the point of placement is within the specified parameters of Table 499.03-1. Adjust the pumping pressure, boom angles and use pumping aids to lower the friction in the piping to meet the specified parameters. Provide a hose at the end of the line that is at least 0.5 inch smaller in diameter than the line on the boom to minimize free-fall and maintain a continuous flow of concrete in the pipe lines and boom during discharge.

Deliver and distribute the concrete at a uniform and adequate rate no more than 10 feet directly in front of the finishing machine by suitable mechanical equipment. For structures with a skew angle greater than fifteen (15) degrees, Orient the finishing machine according to 511.16. For structures with a skew angle greater than fifteen (15) degrees and up to fifty (50) degrees, load the concrete at the skew angle. For structures with a skew angle greater than fifty (50) degrees, load the concrete as close to the skew angle of the structure as possible, but do not allow the leading edge of the concrete placement to exceed twenty (20) feet ahead of the finishing machine.

Place concrete in structures using vibration. Furnish and use sufficient vibration equipment of the type and size approved by the Engineer to properly compact the concrete immediately after it is placed in the forms. The vibrators shall generally be of a type that is applied directly to the concrete and have a frequency of at least 4500 impulses per minute. If the concrete is inaccessible for this method of vibration, apply the vibrators to the outside of the forms.

Do not move concrete using a vibrator. Vibrate freshly deposited concrete at the point deposited. Slowly insert and withdraw the vibrators vertically into the concrete until the concrete is thoroughly compacted but not segregated. During vibration, do not disturb partially hardened concrete.

As necessary, spade along form surfaces, in corners, and in locations impossible to reach with vibrators to ensure smooth surfaces and dense concrete. Closely observe the results obtained on the first concrete placed, and, if necessary, modify the mix according to this specification to secure the best results.

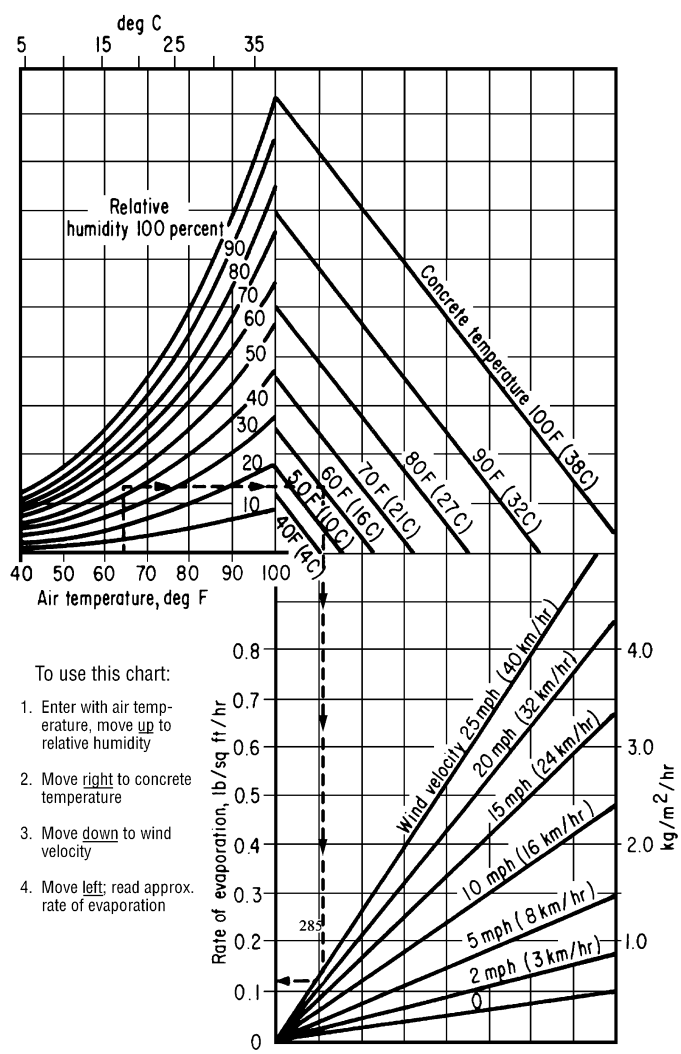


FIGURE 1 ACI 308-81

511.08 Slipform Construction of Bridge Railing. If slipforming, provide finished concrete conforming to the following tolerances from plan dimensions:

TABLE 511.08-1 SLIPFORMED BRIDGE RAILING TOLERANCES

Reinforcing steel cover	-1/2 inch, +1/2 inch
Top width dimension	-0, +1/4 inch
Bottom width dimension	-0, +1/2 inch
Surface flatness	1/4 inch in 10 feet
Vertical alignment (Deviation from a line parallel to the grade line)	1/2 inch in 20 feet Max ±1 inch

Tie all joints and splices in bridge railing reinforcing steel. Before placing concrete, perform a slipforming dry run to verify reinforcing clearance and rigidity of the reinforcing cages. Adjust and stabilize the cage as necessary to establish the required clearances and to ensure the cage will not move during slipforming. The Contractor may add any additional diagonal reinforcing steel between the front and rear vertical reinforcing faces to establish the required rigidity.

Repair or patch honeycombing, cracking, tearing, and other defects immediately after concrete exits the slipform equipment. Completely fill defects with concrete without using water to smooth or close the surface. If the slipforming exhibits more than infrequent defects, stop work and make adjustments to produce a slipformed surface that does not require repairs. Do not broom finish the surface of the bridge railings.

After the concrete initially sets, but before any shrinkage cracks develop, saw control joints 1 1/4 inches deep into the perimeter of the parapet. Generally, initial set is within 6 hours of batching of the concrete. Ensure that all joints are sawed within 24 hours of placement. Saw control joints using an edge guide, fence, or jig to ensure that the joint is straight, true, and aligned on all faces of the parapet. The joint width shall be the width of the saw blade, a nominal 1/4 inch. After the concrete curing period specified in 511.14 has been reached, sawcut at least 4 inches deep around the perimeter of the front face, top and back face of the top portion of parapet, no lower than 12 and ½ inches above the top of the concrete deck slab. Caulk the control joints with a polyurethane or polymeric material conforming to ASTM C 920, Type S.

Slip formed concrete requires different slumps than those listed in Item 499 or other plan specified concrete. Provide a slump such that the concrete exiting the slipform does not pull but is stiff enough to prevent waviness and sags in the finished surfaces. Cure slipform concrete according 511.14, Method A. Because slipformed concrete has a low water-cement ratio, timely application of the water cure is critical in helping control shrinkage cracks.

Furnish platforms as necessary to protect traffic passing under the bridge from falling debris during the slipforming operation, to allow access for completing the finishing operation, and to allow the Engineer access to the outside of the parapet.

The Engineer will inspect the slipformed surface for horizontal cracking no earlier than 21 days after completion of the slipforming operation. Repair all horizontal cracks by epoxy injection. If a concrete sealer was applied, repair damage to the sealer after completing the epoxy injection.

511.09 Construction Joints. If construction joints are shown on the plans, place all concrete between consecutive joints in a continuous operation. Follow the requirements of 511.14 when placing concrete against a construction joint.

Obtain the Engineer's approval before placing any construction joint not shown on the plans or required by 511.07.

Before placing concrete, determine the location where the day's concrete placing ends. If practical, end placing the day's concrete perpendicular to the lines of principal stress and in regions of small shear. Do not install horizontal joints in concrete girders and beams.

Form construction joints using bulkheads with keyways. Locate keyways clear of exposed surfaces by approximately one-third the thickness of the joint. Construct transverse or longitudinal construction joints in deck slabs with keys located between the reinforcing mats and having a depth of ¾ inch.

Where practical, avoid horizontal joints in piers, abutments, and retaining walls, otherwise locate horizontal joints 2 feet or more above the normal water level.

For construction joints not shown on the plans and above ordinary low water, in abutments, and in retaining walls that retain earth fills, install a 36-inch strip of Type 2 membrane waterproofing according to Item 512 to the back of the joint.

Avoid joints in cantilevered members.

Dampen the surface of the concrete of the horizontal construction joints immediately before placing adjoining concrete.

Place and protect horizontal construction joints between bridge slabs and superimposed curbs, parapets, sidewalks, and median strips in the same manner as the remainder of the slab. Cure the construction joints according to 511.14.

Avoid disturbing the bond between protruding reinforcing steel and the deck concrete. If using the curb areas to place the deck, tie and brace the reinforcing steel to prevent its movement.

Where walls or columns support slabs or beams, place concrete in wall or column to the bottom of the slab or beam and allow the concrete to settle for at least 2 hours before placing concrete in the slab or beam.

511.10 Work Stoppage. If the work is unexpectedly interrupted by breakdowns, storms, or other causes, rearrange the freshly deposited concrete to provide a suitable construction joint. If this joint occurs at a section with shear stress, prevent a plane of weakness by providing an adequate mechanical bond across the joint by forming a keyway, inserting reinforcing steel, or by some other means satisfactory to the Engineer.

511.11 Depositing Concrete under Water. Except for cofferdam seals and drilled shafts, do not place concrete under water.

511.12 Depositing and Curing Concrete during Cold Weather. If placing concrete when the atmospheric temperature is 32 °F or less, or if weather forecasts predict these temperatures during the curing period, follow the procedures of this subsection.

Heat the water or aggregate, or both, as necessary to produce concrete with a temperature when placed of at least 50 °F but not greater than 70 °F.

Place concrete against materials with a temperature of greater than 32 °F. If necessary, heat the forms, reinforcing steel, and foundation materials before placing the concrete.

Maintain the concrete surface temperature between 50 and 100 °F for a period of not less than 5 days, except as modified in 511.12.C. After the minimum cure period of 5 days, reduce the concrete surface temperature at a rate not to exceed 20 °F in 24 hours until the concrete surface temperature is within 20 °F of atmospheric temperature.

Install sufficient high-low thermometers to readily determine the concrete surface temperature. For deck slabs, install high-low thermometers to measure deck bottom surfaces, deck fascia surfaces, and deck top surfaces.

Maintain the concrete curing temperature using a heated enclosure, insulated forms, or by flooding, except cure deck slabs less than 10 inches thick using more than just insulated forms.

Remove falsework and open cold weather concrete to traffic according to 511.14.

A. Heated Enclosure. Construct the heated enclosure to surround the top, sides, and bottom of the concrete. Construct strong and wind proof enclosures that contain adequate space to allow free circulation of air around the forms and concrete.

Before placing concrete, construct the enclosure and heating devices to the extent allowed by the concrete operation. As the concreting operation progresses and as soon as possible after placing concrete, complete construction of the enclosures and apply heat. Supply heat by a method that continuously maintains a reasonably uniform temperature throughout the enclosures and does not discolor the concrete.

Vent combustion-type heating devices outside the enclosure.

If dry heat, other than free steam, maintains the enclosure temperature, immediately cover exposed concrete with two thicknesses of burlap. Continuously wet the burlap and, except for required rubbing of the concrete, do not remove the burlap during the heating period.

If wood forms without liners are left in place more than 2 days after the placing of concrete, thoroughly wet the forms at least once each day for the remainder of the heating period. If forms are removed during the heating period, thoroughly drench the concrete with water and, for the remainder of the heating period, cover and wet the concrete with burlap as specified above.

B. Insulation. Install sufficient thermometers to readily determine the concrete surface temperature. If the surface temperature approaches 100 °F, loosen or otherwise vent the forms or insulation to keep the surface temperature within the limits specified above. If insulation does not maintain the minimum required temperature, promptly enclose the concrete as specified in 511.12.A or flood the concrete as specified in 511.12.C.

Use a wind and water resistant insulating material. Ensure edges, corners, and other points of extreme exposure are adequately insulated. Place a tarpaulin or other Engineer approved waterproof cover over the insulation to protect the concrete top surface.

C. Flooding with Water. The Contractor may flood the concrete with water provided flooding does not damage the concrete. Heat the water to a temperature from 50 to 100 °F. The Contractor may stop using heated water after 48 hours if the concrete remains flooded to a depth of 1 foot above its highest elevation for at least the next 120 hours.

511.13 Removal of Forms. To facilitate finishing, remove forms from vertical surfaces that receive a rubbed surface finish as soon as the concrete has hardened sufficiently that rubbing will not damage it.

511.14 Curing and Loading. Remove falsework and open structures to traffic only after the concrete has reached the strength specified by Table 511.14-1. Do not shorten the minimum required Method A curing time regardless of strength test results.

TABLE 511.14-1 LOADING REQUIREMENTS FOR CONCRETE

	Span [1]	Age of Concrete in Days	
		No Split Tensile Test	Split Tensile Test [2]
Removing Falsework	Over 10 feet	14	5
	10 feet or less and all pier caps	7	3
Traffic [3]	Any	14	7

[1] Span is defined as the horizontal distance between faces of the supporting elements when measured parallel to the primary reinforcement.

[2] Applicable only when the average Split Tensile psi for two tests is not less than 450 psi.

[3] When placing concrete for a superstructure between October 15 and March 15, open the deck to traffic no sooner than 30 days after placement.

Take enough specimens to verify compliance with the strength requirements of Table 511.14-1. Obtain samples from the first and last sublots of continuously placed concrete for quantities of 500 yd^3 or less, and one extra set of specimens for each additional 500 yd^3 or fraction thereof. Obtain samples in equally spaced increments throughout the placement as directed by the Engineer. Delays in placements of more than 4 hours are not considered continuously placed and are to be treated as separate placements.

If the air temperature surrounding the concrete is maintained between 32 and 50 °F, and if the provisions of 511.12 do not apply, maintain the concrete above 32 °F for 7 days or until a successful split tensile test conforming to Table 511.14-1, except this time shall not be less than 5 days.

Do not apply loads to or perform work on new concrete until workers and construction materials will not damage the concrete or interfere with its curing. Allow at least 36 hours and until the field cured compressive strength cylinders or maturity results reach 85% f'c; or if using split tensile, the average of two split tensile tests is greater than 450 psi before loading new concrete. Do not interfere with curing of new concrete.

Cure concrete as follows:

TABLE 511.14-2 CURING REQUIREMENTS

Location	Curing Method [1]
Superstructure concrete	Method A
Concrete to which sealer is applied	Method A
Construction joints	Method A
Top surface of concrete deck superstructure concrete	Method A followed by Method B
Concrete with waterproofing	Method A or Method B
All other concrete	Method A or Method B

[1] Method A is water curing. Method B is membrane curing. If using Method B on areas to be waterproofed, remove the curing membrane.

Concrete curing methods are as follows:

A. Method A, Water Curing. With the exception of the top surface of deck superstructure concrete, protect surfaces not covered by forms immediately after final finishing with two thicknesses of wet burlap. Keep burlap wet for at least 7 days by the continuous application of water. If forms are removed before 7 days, immediately drench the exposed concrete with water and cover it with burlap. Continuously apply water to the burlap for the remainder of the curing period.

Instead of continuous application of water, with the exception of the top surface of deck superstructure concrete, the Contractor may cover the wet burlap with white polyethylene sheeting or plastic coated burlap blankets conforming to 705.06. Place plastic coated burlap blankets wet and with the burlap side against the previous layer of wet burlap. Sufficiently lap and secure adjoining plastic coated blankets or polyethylene sheets at the laps and edges to form a seal that maintains the concrete wet at laps and edges. Cover white polyethylene sheeting or plastic coated blankets containing holes or tears with an additional covering of plastic sheeting or blankets as directed by the Engineer.

Cover the top surface of deck superstructure concrete with a single layer of clean wet burlap after it is bull floated if necessary, and finished. Keep the burlap wet by a continuous flow of water through soaker hoses and cover the hoses with a 4 mils white opaque polyethylene film for 7 days. After 7 days, allow the surface of the deck to dry.

After curing the top surface of the deck superstructure concrete for 7 days, remove the burlap and standing water. Within 12 hours after removing the burlap, apply a curing membrane and cure the concrete according to Method B.

B. Method B, Membrane Curing. Immediately after the free water has disappeared on surfaces not protected by forms, apply curing material conforming to 705.07, Type 1 or 1D. If forms are removed before the end of the 7-day curing period, apply curing material on the concrete exposed by removing the forms.

Thoroughly mix curing material immediately before use. Apply the membrane curing material at the rate of at least 1 gallon per 200 square feet of surface and in a fine mist to provide a continuous, uniform, and water impermeable film without marring the concrete surface

Do not allow workers, materials, and equipment on the concrete during the curing period, unless adequately protecting the membrane curing material from damage.

If the film is broken or damaged during the specified curing period, reapply curing material as specified above to the damaged or affected areas.

511.15 Surface Finish. For concrete that is to be sealed according to 512.03, perform surface profiling according to 512.03.F, immediately after removing forms, Clean, dampen, and fill with mortar all cavities produced by form ties, honeycomb spots, broken corners or edges, and other defects. Use a mortar of the same proportions used in the concrete being finished. Finish other contiguous exposed surfaces on the structure in a similar manner and to the extent required to produce a uniform appearance.

On all exposed surfaces, remove fins and irregular projections with a stone or power grinder, taking care to avoid contrasting surface textures.

A. Grout Cleaning. If grout cleaning is shown on the plans or necessary for corrective work, wet the concrete surface and then uniformly cover the concrete with a grout consisting of one part cement, 1 1/2 parts fine sand conforming to 703.03, and sufficient water to produce a mortar with the consistency of thick paint. Use white portland cement in the grout in the quantity determined by the Engineer necessary to match the color of the concrete. Uniformly apply the grout with brushes or spray guns, completely filling air bubbles and holes. Immediately after applying the grout, vigorously scour the concrete surface with a cork or other suitable float. While the grout is still in a plastic condition and while the grout does not pull from the holes or depressions, finish the surface with a sponge rubber or other suitable float, removing excess grout. After the grout thoroughly dries, vigorously rub the surface with dry burlap, removing dried grout until there is no visible film of grout remaining on the surface. Perform the entire cleaning operation of each area on the same day. Remove dark spots or streaks that remain after the cleaning operation using a fine grained silicon carbide stone. Stop rubbing with the silicon carbide stone before the surface texture changes. Unless otherwise directed by the Engineer, perform grout cleaning during the final project clean up.

B. Rubbed Finish. If a rubbed finish is shown on the plans, if possible, remove forms within 2 days after placing concrete. Finish the surface as specified above to correct defects. After the mortar used for finishing is thoroughly set, and for a minimum of 2 hours before starting the rubbed finish, thoroughly saturate the concrete with water.

Rub surfaces to be finished with a medium coarse silicon carbide stone until all form marks, projections, and irregularities are removed, all voids are filled, and a uniform surface is obtained. Leave the paste produced by rubbing in place. Other than water, do not apply additional material to the surface. After placing concrete above the finishing area, obtain the final finish by rubbing the concrete with a fine silicon carbide stone and water until the entire surface is of a smooth texture and uniform in color. Protect surfaces with a rubbed finish from damage caused by subsequent construction operations. If damaged, clean and refinish the surface as specified above.

511.16 Roadway Finish. Finish and test concrete deck slabs according to 451.13. Do not groove or broom finish a strip of surface 9 to 12 inches wide adjacent to curbs and barriers. Provide a broom drag finish on concrete deck slabs in the longitudinal or transverse direction.

The Engineer will approve the finishing machine. Provide a self-propelled machine with forward and reverse drive mechanisms that enable precise control of machine velocity in both directions. The machine shall have two rotating rollers, leveling augers, and either a vibrating pan or vibrating rollers. Field verify that the vibrating frequency of the pans or rollers are from 1500 to 5000 pulses per minute. Do not use vibrating rollers that have fins protruding more then 1/4 inch from the roller. Use a finishing machine capable of finishing transversely while traveling in both directions across the deck. Provide screeds capable of rising above the concrete surface. Provide a finishing machine capable of finishing the full width of the decks between curbs or parapet walls. The wheels of the finishing machine shall run on temporary riding rails adequately supported on the structural steel or falsework of the deck. Make the rail and rail supports of steel and arrange the rail and rail supports so that the weight of the finishing machine and the operator cause zero vertical deflection while traveling across the deck. Ensure the rail is straight, with no sections exceeding a tolerance of 1/8 inch in 10 feet in any direction. Elevate support rails a sufficient distance above the slab to allow the simultaneous hand finishing of areas not machine finished. Fabricate and install rail supports to allow removal to at least 2 inches below the top of the slab. Fill holes formed by the removal of rail supports during the final finishing of the slab.

For structures with a skew angle greater than fifteen (15) degrees and up to fifty (50) degrees, place the finishing machine within 5° of the skew angle of the structure. For structures with a skew angle greater than fifty (50) degrees, place the finishing machine at fifty (50) degrees.

511.17 Bridge Deck Grooving. After water curing the concrete and either before applying curing compound or some period after applying curing compound and before opening the bridge to traffic, saw longitudinal grooves into the deck, unless specified otherwise in the plans. If sawing grooves after applying the curing compound and the concrete deck is less than 30 days old, reapply the curing compound after removing standing water, within 12 hours after sawing grooves in the deck.

Use diamond blades mounted on a multi-blade arbor on self-propelled machines that were built for grooving of concrete surfaces. The groove machines shall have depth control devices that detect variations in the pavement surface and adjust the cutting head height to maintain the specified depth of the groove. The grooving machines shall have devices to control alignment. Do not use flailing or impact type grooving equipment. More than one size grooving machine may be required in order to saw the grooves as specified. Maintain a minimum of ¾ inch to a maximum of 2 ¼ inches transverse distance between adjacent passes of the grooving machine head.

Provide an experienced technician to supervise the location, alignment, layout, dimension, and grooving of the surface.

Saw grooves parallel to the bridge centerline in a continuous pattern across the surface. Begin and end sawing 9 to 12 inches from any device in place in a bridge deck, such as scuppers or expansion joints. Stop sawing a minimum of 2 inches to a maximum of 24 inches from skewed expansion joints. Maintain a clearance of a minimum of 2 inches and a maximum of 4 inches from the grooves to longitudinal joints in the deck. Maintain a minimum clearance of 9 inches to a maximum of 30 inches clearance between the grooves and the curb or parapet toe. However, at no

point shall un-grooved portions of deck extend beyond edge line and into the temporary or permanent travelled lanes. Saw grooves in a uniform pattern spaced at 3/4 inch minus 1/4 inch or plus 0. Saw grooves approximately 0.15 inches deep and 0.10 inches wide.

For staged, or phase bridge deck work, saw the grooves parallel to the final, permanent bridge centerline. If the different stages or phases of the bridge deck work occur within one construction season, any stage opened to traffic shall receive an interim coarse broom finish during placement, then saw the longitudinal grooves after the final stage. The interim broom finish will not be allowed as a surface texture when opened to traffic over a winter season. Saw longitudinal grooves in the deck prior to opening to traffic for a winter season.

For bridge decks that widen from one end to the other, saw the longitudinal grooves parallel to the centerline of the roadway. On the side of the bridge that widens, saw the longitudinal grooves to follow the edge line. Saw longitudinal grooves in the gore areas, avoiding the overlapping of grooves.

At the beginning of each work shift, furnish a full complement of grooving blades with each saw that are capable of cutting grooves of the specified width, depth, and spacing.

If during the work, a single grooving blade on a machine becomes incapable of cutting a groove, continue work for the remainder of the work shift. The Contractor is not required to cut the groove omitted because of the failed blade. Should two or more grooving blades on a machine become incapable of cutting grooves, cease operating the machine until it is repaired.

Continuously remove all slurry and remaining residue from the grooving operation and leave the deck surface in a clean condition. Prevent residue from grooving operations from flowing across shoulders or across lanes occupied by public traffic or from flowing into gutters or other drainage facilities. Remove solid residue before the residue is blown by passing traffic or by wind.

Provide water as necessary to saw grooves according to this subsection.

511.18 Sidewalk Finish. After placing, strike off the concrete with a template and finish the concrete with a float to produce a sandy texture.

511.19 Joints, Cracks, Scaling and Spalls. After completing all curing operations and allowing the deck to thoroughly dry, seal the following areas with a high molecular weight methacrylate (HMWM) sealer. Flood the areas and squeegee off the excess material as specified in Item 512 before opening the deck to traffic:

A. Transverse joints in the deck.

B. Joints between the concrete deck and steel end dams.

C. Longitudinal joints in the deck.

D. Longitudinal joints between the deck and safety curb, barriers, and parapets, etc.

E. Cracks discovered in the deck of the top and bottom surfaces before opening the deck to traffic, that are 10 mils or 0.010 inches or less in width.

Determine the extent (and effect) of deck cracking on the top and bottom surface area, that are 10 mils or 0.010 inches or more in width, of deck scaling that is greater than 0.250 inches deep on the deck surface, and of deck spalling on more than one area or an area greater than 32 square yards, and submit a proposed repair plan to the Engineer. The City will determine if the proposed repair methods are acceptable.

511.20 Compressive Strength. Sample and test concrete strength according to 511.04.

The Engineer will evaluate the strength results as follows:

If a single compressive strength test result is less than f'c the material will be considered unacceptable material and the City will determine acceptance according to 106.07.

If three or more compressive strength test results are less than *f'c* the Engineer will require an investigation of the reasons for the consistent low strengths. Until the investigation is completed to the satisfaction of the Engineer no additional placements of the concrete JMF will be made. Investigations should include all facets of the concrete operation including batching, mixing, delivery, clean up, sampling, testing, etc. If the Engineer is unsatisfied with the results of the investigation, the JMF will become not approved. Develop and submit a new JMF conforming to the requirements of 499.03.

511.21 Air Content. The City will test the air content as directed by the Engineer.

Any concrete with air results outside the requirements of Table 499.03-1 that is placed into the structure is unacceptable material, according to Item 106.07. The amount of unacceptable material will be the amount represented by the test result. Reevaluate the unacceptable material at no cost to the City as follows:

1. The City will core the location containing the unacceptable concrete. Patch the core hole with approved materials.

a. For concrete with high air content, the City will test a core for compressive strength. Concrete with a strength of f'c may be left in place.

b. For concrete with low air content, the City will determine the in-place hardened air content, specific surface and spacing factor according to ASTM C 457. Remove and replace unacceptable materials with specific surface results less than 600 in^{-1} or spacing factor results of more than 0.008 in.

511.22 Not Used.

511.23 Method of Measurement. The City will measure the appropriate concrete item by the number of cubic yards determined by calculations from plan dimensions, in place, completed and accepted.

The City will make deductions for portions of primary structural members embedded in concrete. The City will not make deductions for the volume of reinforcing steel, conduits or embedded piles.

Superstructure concrete includes the concrete in deflective parapets not having a metallic railing.

The City may measure deck concrete by either volume or area using plan dimensions.

511.24 Basis of Payment. The City will pay for accepted quantities of concrete as follows.

Work necessary to adjust seat elevations and deck haunches for prestressed beam members is incidental to the affected structural concrete items. The City will pay for final quantities as measured and field verified.

The City will not pay for additional reinforcing steel required to adequately stabilize the cages.

The City will not pay for repairs to horizontal cracks by epoxy injection or, if a concrete sealer was applied, for repairs to the sealer after the completing the epoxy injection.

The City will not pay extra for any type of surface finish specified in 511.15, the cost being considered as included in the price bid for concrete.

If the Contractor elects to saw the deck after applying the curing compound, the City will not pay to reapply the curing compound.

All costs for sealing as specified in 511.19 are incidental to the appropriate concrete item. The City will not make separate payment for sealing.

The City will not pay separately for the concrete cylinder curing box (CCCB).

The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
511	Cubic Yard	Class COC ___ Concrete, _____

ITEM 512 TREATING CONCRETE

512.01 Description
512.02 Materials
512.03 Sealing of Concrete Surfaces
512.04 Sealing Concrete Bridge Decks with HMWM Resin
512.05 Soluble Reactive Silicate (SRS) Concrete Treatment
512.06 Treating Concrete Bridge Decks with Gravity-Fed Resin
512.07 Sealing Cracks by Epoxy Injection
512.08 Waterproofing
512.09 Method of Measurement
512.10 Basis of Payment

512.01 Description. This work consists of sealing and treating concrete surfaces, sealing cracks in concrete, and applying waterproofing to structures.

512.02 Materials. Furnish materials conforming to:

Asphalt cement.....702.01 (PG 64 - 22)
Asphalt primer for waterproofing.....
.....702.02 (RC-70 or RC-250), 702.05
HMWM Resin..... 705.15
Epoxy-Urethane Sealer 705.23.A
Non-epoxy Sealer.....705.23.B
Soluble Reactive Silicate (SRS)..... 705.24
Gravity Fed Resin 705.25
Epoxy Injection Materials 705.26
Sand..... 703 with the following exceptions:
Maximum moisture content of 0.5 of the percent of absorption when treated according to California Test 226.
Gradation:

Sieve Size	Total Percent Passing
No. 4	100
No. 8	90 to 100
No. 20	5 to 15
No. 50	0 to 5

Emulsified asphalt primer, ... 702.04 (MS-2, SS-1)
Asphalt for waterproofing 702.06
Hot applied joint sealer 705.04

Type 3 membrane primer 705.04
Waterproofing fabric 711.24
Sheet Type 2 membrane waterproofing..... 711.25
Sheet Type 3 membrane waterproofing..... 711.29

512.03 Sealing of Concrete Surfaces. This work consists of applying an approved sealer on existing and new concrete surface areas after the concrete is cured and repairs completed and cured. Apply the sealer to locations described in the plans. Apply the sealer listed in the pay item description. Choose a type of sealer if no sealer is listed in the pay item description.

A. Equipment. Use application equipment recommended by the sealer manufacturer. Use spray equipment, tanks, hoses, brooms, rollers, coaters, squeegees, etc., that are clean, free of foreign matter, oil residue and water.

B. Mixing. Mix the sealer according to the manufacturer's recommended procedures. Furnish the Engineer with the manufacturer's application instructions. Do not mix or apply the sealer until the manufacturer's written recommendations are supplied to the Engineer. Mix and maintain materials at a uniform consistency during application.

C. Storage. Store all sealer components in tightly sealed containers, in a dry location, and as recommended by the manufacturer. Deliver unopened drums or containers of the sealer or sealer components to the job site with the manufacturer's numbered seal intact.

D. Application submittals. At least five (5) days before sealing, provide the Engineer the sealer manufacturer's written requirements for application equipment, mixing equipment, mixing procedures, mixing time, storage requirements, recoat times and temperatures, and MSDS sheets.

E. Surface Condition. Apply sealers only to surfaces which are dry, free from dust, dirt, oil, wax, curing compounds, efflorescence, laitance, coatings and other foreign materials. Visually inspect all surfaces before applying sealer. Remove all structurally unsound surfaces and weak sections.

Perform all concrete patching prior to surface profiling. Perform concrete patching on areas identified by the Engineer according to Item 519. Cure repaired areas for at least seven (7) days.

Air dry all concrete surfaces for at least ten (10) days after completion of required curing.

For accelerated cure of precast concrete, obtain the required 28 day strength and air dry the surfaces at least ten (10) days after completing accelerated cure.

F. Surface Preparation and Profiling. Remove dust, dirt, oil, wax, curing compounds, efflorescence, laitance, coatings and other foreign materials from surfaces to be sealed.

For Epoxy-Urethane sealers, use one or both of the following methods to produce a surface profile that feels and looks like 100 grit sandpaper or coarser. Provide the Engineer sandpaper for comparison. Perform the ASTM D7682-12, Method B, Standard Test Method for Replication and Measurement of Concrete Surface Profile Using Replica Putty to obtain a replica coupon of the prepared concrete surface on a flat, test section, on the first day of production, and as requested by the Engineer. With a micrometer, measure the surface profile obtained on the coupon, and provide the coupon to the Engineer.

1. Water blast at 7,000 psi minimum,
2. Abrasive blast, followed by air brooming or power sweeping, to remove dust and sand from the surface and opened pores, or
3. Use a combination of water blast and abrasive blast.

Install suitable traps, filters, drip pans and other separation devices in the cleaning equipment so oil and other foreign material are not deposited on the surface.

If the concrete surface had curing compound applied, acid test the surface after blasting to see if the curing compound was removed. Perform the acid test for every 500 square feet. Use a solution of 1 part 20º Baume muriatic acid and 2 parts water. Apply 4 to 5 drops to the concrete surface. If foaming/fizzing occurs the curing compound is removed. Rinse the tested location with an ammonia solution to neutralize the concrete area tested (1 cup ammonia to 5 gallons water).

(NOTE: Muriatic acid and ammonia can be bought in a hardware store. Muriatic acid is used to clean masonry. Only dilute by pouring the acid into the water. DO NOT pour the water into the acid.)

When surfaces show intermittent or no foaming, use chemicals or other cleaning compounds to remove the curing compounds. Only use products approved by the sealer manufacturer. Furnish the Engineer documentation of the sealer manufacturer's approval and method to test if materials are removed.

Ensure that all wastes generated by the surface preparation operation are managed in accordance with 107.19.

G. Application and Coverage. Apply the sealer between twelve (12) hours and 48 hours after surface preparation by water blasting methods. Apply the sealer within 48 hours after surface preparation by abrasive blasting methods Do not apply sealer if rain is anticipated within six (6) hours after application. Clearly mark where the sealer application stops if not continuous.

1. Epoxy / Urethane sealers.

a. Apply the epoxy coat of the epoxy-urethane sealer at the coverage rate of 120 square feet per gallon. Use a coverage rate of 150 square feet per gallon when the ODOT's Qualified Products List for the epoxy authorizes it. Apply the urethane coat of the epoxy-urethane sealer

at a rate of 200 square feet per gallon. When surfaces are not smooth and flat, adjust the given coverage rates by the following formulas to determine the correct coverage rate.

(1) For surfaces using large stone liners and standard concrete = specified coverage rate (sq ft/gal) × 0.8

(2) For surfaces using large stone liners and porous concrete = specified coverage rate (sq ft/gal) × 0.7

(3) For surfaces using fluted liners and standard concrete = specified coverage rate (sq ft/gal) × 0.5

b. Provide documentation to the Engineer that the ambient, surface and material temperature is 50 ºF or above, 5 ºF higher than the dew point, and the relative humidity is 80% or below during the application of the sealer.

c. Apply with a brush, squeegee, roller or spraying equipment and as recommended by the manufacturer.

d. Apply one coat of epoxy and one coat of the urethane top coat. Time between coats shall meet the manufacturer's written recommendation provided to the Engineer during 512.03.D. Use epoxy and urethane from the same manufacturer. Achieve specified coverage regardless of the number of passes per coat.

e. Tint so the final color is Federal Color Standard No. 17778 - Light Neutral. Pigment content shall be limited so as not to reduce sealing effectiveness of the second coat. Refer to the plans for colors for specific projects.

f. Sags and runs are not acceptable in the sealer.

g. For sealed sidewalks or other horizontal surfaces with repetitive foot traffic or vehicular traffic, integrate 1 1/2 lbs per square yard of silica sand into the surface of the second coat to produce a nonskid surface satisfactory to the Engineer.

h. From the date of Final Acceptance, provide a five (5) year warranty for coating failure such as scaling, flaking, delamination, or other similar defects.

2. Non-epoxy sealer.

a. Apply the sealer according to the manufacturer's recommended mode of application and under the observation of the Engineer.

b. Coverage.

(1) Surfaces subject to abrasive wear (bridge decks, bridge deck shoulders and sidewalks); Minimum, one gallon of sealer for each 100 square feet.

(2) Curbs, vertical surfaces of beams and deck slabs subject to direct roadway drainage; Minimum, one gallon for each 125 square feet.

(3) Other surfaces (for example, parapets, abutments, pier caps and median dividers); Minimum, one gallon for each 150 square feet.

Stone or fluted formed concrete surfaces may require additional sealer materials for coverage.

c. Apply sealer on horizontal surfaces in a one-pass operation at the required coverage. An acceptable application procedure consists of saturating the surface and waiting a few seconds for the sealer to completely penetrate the concrete surface. Broom in the sealer if recommended by the manufacturer.

d. Apply sealer on vertical surfaces to saturate the surface. The surface is saturated when runs of 6 to 12 inches develop. Apply additional passes in 10 to 15 minute intervals until the coverage rate is achieved. Apply sealers with brush or roller if recommended by the manufacturer.

e. After 10 to 15 minutes, squeegee off excess material on smooth finished or dense concretes where the required coverage is not absorbed.

f. Tint clear non-epoxy sealers with a vanishing dye that will not damage the concrete.

g. Do not apply sealer if the ambient temperature is below 40 °F (5 °C) or will fall below 32 °F (0 °C) within 12 hours after application.

H. Test Site/Application. Apply epoxy-urethane or non-epoxy sealer to measured coverage areas, both on horizontal and vertical surfaces, and on different concrete types, demonstrating:

1. The project's visual effects for the epoxy-urethane sealer application at the required coverage rate.

2. Visually, the absorption necessary to achieve the specified coverage rate for the non-epoxy sealer. Use at least ½ gallon of sealer, following the manufacturer's recommended method of application, for the total of the test surfaces.

3. Apply to the deck, safety curb or sidewalk for the horizontal test surfaces and use an abutment parapet or pier face for the vertical test surface so different textures are tested.

I. Appearance. Epoxy-Urethane sealers: Uniform appearance and the final color shall visually match the test section. Recoating, removal and re-application or other methods recommended by the manufacturer will be required to correct final appearance. Non-Epoxy Sealers: The sealer shall result in a uniform appearance.

J. Traffic. Allow traffic on deck shoulder areas after 12 hours of drying time for an epoxy-urethane sealer. Keep traffic off a non-epoxy sealer until the sealer is dry.

K. Safety Precautions. Follow precautions defined on the manufacturer's MSDS. Provide the Engineer a copy of the MSDS sheet for information before any work commences.

L. Protection of Adjoining Surfaces and the Public. Protect the public during all operations, especially when applying sealer to the fascia or the underside portions of a bridge that spans an area used by the public.

During sealing, mask off, or use other means of protection, for surfaces not being sealed. Protect asphalt and mastic type surfaces from spillage and heavy overspray. Do not apply sealers to joint sealants which have not cured according to the manufacturer's instructions. Joint sealants, traffic paints and asphalt overlays may be applied to the treated surfaces 48 hours after the sealer has been applied. Protect nearby steel, aluminum or glass surfaces when non-epoxy overspray could be deposited on those surfaces.

M. Environmental Requirements. Protect plants and vegetation from overspray by covering with drop cloths.

N. Superintendent. In addition to the requirements of 105.06, the Superintendent must successfully complete a Sealing of Concrete Surfaces training pre-qualification course offered by ODOT. The Superintendent must have completed the course within the past four years and received an individual course certificate. Present certificate to the Engineer prior to beginning the sealing of concrete surfaces work. Work will not be permitted to begin until after the Superintendent provides a valid course certificate.

512.04 Sealing Concrete Bridge Decks with HMWM Resin. This work shall consist of preparing and treating the concrete wearing surfaces of bridge decks with a penetrating sealer in accordance with these specifications, in reasonably close conformity with the plans and the manufacturer's recommendation and as directed by the Engineer.

A. Limitations. Do not perform this work during the period beginning November 1st and ending March 31st.

B. Surface Preparation. Remove roadway dirt and debris from the area of the deck to be treated. Sweep, abrasive blast, then with the use of a manual or power broom sweep and blow with compressed air so that the surfaces to which the sealer is to be applied is dry and free of dust and dirt. Use high pressure compressed air to blow all loose material from visible cracks. Fit the cleaning equipment with suitable traps, filters, drip pans, driers and other devices to prevent oil and other foreign material from being deposited on the surface. Do not allow traffic on the clean surface prior to application of the sealer. Remove existing pavement markings using a method as specified in 614.11.G.1.a. The cost of removal is incidental to the Work. Remove all traces of asphalt or petroleum products and concrete curing seals by abrasive blasting prior to air sweeping.

C. Installation. Provide a compatible promoter/initiator system capable of providing the same physical qualities of the hardened resin as if promoted/initiated with 2 percent cobalt naphthanate (6 percent) and 2 percent cumene hydroperoxide. Store materials at 65 to 80 °F. Provide a system that has a resin gel time of not less than 40 minutes to not more than 1 1/2 hours at the time and temperature of application.

Adjust the gel time to compensate for the change in temperature throughout the day. The temperature of the surfaces to be treated may range from 50 °F to 120 °F. Arrange to have a technical representative on site to provide mixing proportions equipment suitability, and safety advice. Any conflict between these provisions and representative's advice shall be resolved at the job site. The technical representative shall remain at the job site until such time as the Engineer and technical representative agree that the Contractor is qualified in all aspects of the application of the sealer.

Do not allow the promoter and initiator, if supplied separate from the resin, to contact each other directly. Do not store containers of promoter or initiators together in a manner that will allow leakage or spillage from one to contact the containers or materials of the other.

Machine application of the resin may be performed by using a two-part resin system utilizing a promoted resin for one part and an initiated resin for the other part. This two-part resin system may be combined at a spray bar through positive displacement atomization of the resin. Do not use compressed air to produce the spray.

Use appropriate cleaning and flushing of equipment, tools, etc., with an appropriate solvent, as approved by the Engineer, in such a manner to minimize personal and environmental hazards. Advise workman that the resin will soften gum rubber soles, and a face-mask should be used to protect from accidental splashes. Clothing and leather saturated with resin will harden and become useless.

Prior to resin application the surface to be treated shall be visibly dry and its temperature between 50º F and 120º F. Do not apply the resin within 24 hours after a rain or when rain is forecast within 12 hours or when the ambient air temperature is below 50º F. Pre-mark the deck to control mixed material usage and to provide a rate of application of approximately 100 square feet per gallon. The exact rate shall be determined by the Engineer prior to commencing full-scale deck treatment operations.

Before using the material, submit to the Engineer copies of the manufacturer certified test data showing that the material complies with the requirements of this specification. The test data shall be developed by an independent approved testing laboratory, and shall include the brand name of the material, name of manufacturer, number of the lot tested and date of manufacture. When the material has been approved by the Engineer, further testing by the manufacturer will not be required unless the formulation of manufacturing process has been changed, in which case new certified test results will be required. The manufacturer shall certify that the formulation is the same as that for which data has been submitted. The state reserves the right to sample and test delivered lots for compliance.

Flood the deck surfaces resin, allowing penetration into the concrete and filling of all cracks. Limit the initiated mix of promoted resin to 5 gallons at a time for manual application. A significant increase in viscosity shall be cause for rejection. Apply the treatment within 5 minutes after complete mixing. Redistribute excess material by squeegee or brooms within 10 minutes after application.

Take all steps necessary to prevent the resin from flowing into lanes open to traffic. Broadcast sand over the entire treated area of the bridge deck by mechanical means to affect a uniform coverage of 0.80 to 1.2 pounds per square yard. The sand shall be uniformly graded aggregate conforming to the quality requirements of Item 703 and shall conform to the following limits for grading:

Sieve Size	Total Percent Passing
No. 4	100
No. 8	90 to 100
No. 20	5 to 15
No. 50	0 to 5

It is the intention of the specification to allow the use of commercially available blast sands applied by a common lawn broadcast type seeder/spreader. Place sand between 10 to 15 minutes behind the resin spreading front and before any jelling of the resin occurs. If the surface contains large deep cracks, the low-viscosity liquid could run completely through the concrete slab. Apply a second coat in these areas after the first coat has started to cure.

Before the monomer hardens, fill imperfections or spalls with standing liquid with commercial quality concrete or sandblast sand, and finished to a uniform surface. The sand shall have a maximum moisture content of 0.5 of the percent of absorption when tested in accordance to a California Test 226.

Do not permit traffic and equipment on the tested deck until it is tack free and a minimum of 6 hours have elapsed since treatment and the sand cover adheres sufficiently to resist brushing by hand. Protect the treatment from moisture for not less than 4 hours after placement.

512.05 Soluble Reactive Silicate (SRS) Concrete Treatment. This item consist of the necessary labor, materials and equipment to prepare and treat portland cement concrete surfaces with a reactive silicate sealer meeting these specifications.

A. Equipment. Use application equipment that is recommended by the manufacturer. Use spray equipment, tanks, hoses, brooms, rollers, coaters, squeegees, etc., that are thoroughly clean, free of foreign matter, oil residue and water prior to applying the treatment.

B. Cleaning and Surface Preparation. Do not begin sealing until all concrete repairs have been completed and reached the design strength of the patch material.

Thoroughly clean the surface to remove dust, dirt, oil, wax, curing components, efflorescence, laitance, coatings and other foreign materials. Sweep, abrasive blast, then with the use of a manual or power broom sweep and blow with compressed air so that the surfaces to which the sealer is to be applied is dry and free of dust and dirt. Use high pressure compressed air to blow all loose material from visible cracks. Obtain the approval of the manufacturer or its representative before the use of chemicals and other cleaning compounds to facilitate the removal of these foreign materials. Apply the treatment within 48 hours following surface preparation.

Fit cleaning equipment with suitable traps, filters, drip pans and other devices to prevent oil and other foreign material from being deposited on the surface.

C. Test Application. Treat a measured test coverage area on horizontal and vertical surfaces of the different components of the structure to be treated for the purpose of demonstrating the desired physical and visual effect of an application or of obtaining a visual illustration of the absorption necessary to achieve the specified coverage rate prior to final application. In the latter case, use at least ½ gallon of treatment following the manufacturer's recommended method of application for the total of the test surfaces. Locate horizontal test surfaces on the deck and on the safety curb or sidewalk and locate vertical test surfaces on an abutment parapet and pier face so that the different textures are displayed.

D. Application. Apply the concrete treatment to concrete surfaces as designated on the plans. Apply the SRS by thoroughly saturating the concrete surfaces at an application rate specified by the manufacturer.

Apply the SRS when the concrete surface temperature is above 35º F. Use a surface thermometer on the concrete to establish the temperature of the concrete if the air temperature at the time of application is 45º F or below.

Spread the SRS from puddles to dry areas.

If unable to complete the entire application continuously, note and clearly mark the location where the application was stopped.

E. Protection of Adjoining Surfaces and the Public. Protect by masking off or by other means adjoining surfaces of the structure which are not to be sealed when applying a treatment. Make provision to protect the public when treating the fascia of a bridge and/or portions of the underside of the deck of a bridge that spans an area used by the public.

Protect asphalt and mastic type surfaces from spillage and heavy overspray. Do not apply joint sealants, traffic paints and asphalt overlays to the treated surfaces until 48 hours after the treatment has been applied. Cover adjoining and nearby surfaces of aluminum or glass where there is a possibility of the treatment being deposited on the surfaces.

Protect plants and vegetation from overspray by covering with drop cloths. Follow precautions as indicated on the manufacturer’s MSDS.

F. Opening to Traffic. Only allow traffic on a deck after a treated area does not track.

512.06 Treating Concrete Bridge Decks with Gravity-Fed Resin. This work shall consist of preparing and treating the concrete bridge deck with a gravity-fed crack welding system in accordance with these specifications in reasonably close conformity with the plans and the manufacturer’s recommendations and as directed by the Engineer.

A. Limitations. Do not perform this work during the period beginning November 1st and ending March 31st.

Prior to resin application insure that the surface to be treated is visibly dry with a temperature between 40 °F and 100 °F. Do not apply the resin within 24 hours after a rain, during rain, when rain is forecast within 12 hours or when the ambient air temperature is below 40 °F.

B. Surface Preparation. First remove roadway dirt and debris from the area to be treated. Sweep abrasive blasted surfaces to which the sealer is to be applied, then manual or power broom swept and blown with compressed air so that they are dry and free of dust and dirt. Use high pressure compressed air to blow all loose material from visible cracks. Use a high pressure water blast followed by an air blast if particles are highly embedded in the cracks, to clean cracks. Fit the cleaning equipment with suitable traps, filters, drip pans, dryers and other devices to prevent oil and other foreign material from being deposited on the surface. Do not allow traffic on the clean surfaces prior to application of the sealer. Remove existing pavement markings using a method as specified in 614.11.G.1.a. The cost of removal is incidental to the Work. Remove all traces of asphalt or petroleum products and concrete curing by the abrasive blasting prior to air sweeping.

C. Application. Pre-mark the deck to control mixed material usage and to provide a rate of application of approximately 100 to 150 square feet per gallon. The Engineer will determine the exact rate but will not exceed 150 square feet per gallon. Flood the area to be sealed with resin. Allow the resin to penetrate into the concrete and fill all cracks. Mix the resin to a limit of 5 gallons at a time for manual application. Reject resin with a significant increase in viscosity. Redistribute excess material by a squeegee within 10 minutes after application. Front and back movement with the squeegee is recommended over cracks and patch perimeters to enhance penetration. Take all steps necessary to prevent the resin from flowing into lanes open to traffic. Broadcast sand over the entire sealed area of the bridge deck by mechanical means to effect a uniform coverage per manufacturer's recommendations.

Protect the treatment from moisture for not less than 6 hours after placement.

D. Traffic. Do not permit traffic on the treated deck until the resin is tack free, a minimum of 6 hours has elapsed since treatment, and the sand cover adheres sufficiently to resist brushing off by hand.

512.07 Sealing Cracks by Epoxy Injection. This specification covers the repair of dry, moist or wet cracks or fractures that are 2 to 100 mils in thickness in reinforced concrete members. The repair is by means of an epoxy injection system. This system shall consist of a paste epoxy used to seal the surface cracks and an injection epoxy used under low pressure, 200 psi max., to penetrate and fill the cracks and bond the crack surfaces together. Material for each epoxy shall consist of a two-component modified resin bonding system. The unmodified resin shall be known as Component A and the hardener as Component B.

Arrange to have a manufacturer's representative at the job site to familiarize him and the Engineer with the epoxy materials, application procedures and recommended pressure practice. This representative shall direct at least one complete crack or area injection and be assured prior to his departure from the project that the personnel are adequately informed to satisfactorily perform the remaining repairs.

Furnish the Engineer a copy of the manufacturer's comprehensive preparation, mixing and application instructions which have been developed especially for use with the proposed epoxy injection system. Ensure that any significant changes to these instructions which are recommended by the representative for an unanticipated situation have been approved by the Engineer prior to the adoption of such changes.

Clean concrete surfaces adjacent to the cracks to be sealed only to the extent necessary to achieve an adequate bond with the paste epoxy, and only by procedures which will not cause abrasive grits or concrete dust to penetrate the cracks. Do not permit the use of solvents or thinners in cracks or on bonding surfaces.

Install injection ports or tees in cracks to be injected. Space injection ports or tees at 6 to 12 inches vertically and 6 to 18 inches horizontally but in no case closer together than the thickness of the concrete member if full depth penetration is desired unless otherwise specified or directed. Set ports or tees in dust free holes made either with vacuum drills or chipping hammers. Seal all surface cracks in the area to be repaired, after injection ports or tees have been inserted into the holes, with paste epoxy between ports to ensure retention of the pressure injected epoxy within the confines of the member. The City will allow an alternative procedure of sealing the cracks before the injection holes have been made. Limit the application of paste epoxy to clean and dry surfaces. Limit substrate temperatures to not less than 45 °F during epoxy applications.

Begin the epoxy injection at the bottom of the fractured area and progress upward using a port or tee filling sequence that will ensure the filling of the lowermost injection ports or tees first.

Establish injection procedures and the depths and spacings of holes at injection ports or tees. Use epoxy with flow characteristics and injection pressure that ensure no further damage will be done to the member being repaired. Ensure that the epoxy will first fill the innermost portion of the cracked concrete and that the potential for creating voids within the crack or epoxy will be minimized.

Remove the injection ports or tees flush with the concrete surface after the fractured area has been filled and the epoxy has partially cured (24 hours at ambient temperature not less than 60 °F, otherwise not less than 48 hours). Roughen the surfaces of the repaired areas to achieve uniform surface texture. Remove any injection epoxy runs or spills from concrete surfaces.

Obtain two 4-inch diameter core samples in the first 100 linear feet of crack repaired and one core for each 100 linear feet thereafter. Take the core samples from locations determined by the Engineer and for the full crack depth. The Engineer will visually examine the cores to determine the extent of epoxy penetration. Repair the core holes in the concrete with material specified in 705.21.

512.08 Waterproofing.

A. General. Apply an even and uniform coating of asphalt materials using brushes, squeegees, or spray equipment.

If using spray equipment, provide portable power pressure type spraying equipment capable of being moved to the location of the waterproofing operation.

Protect concrete surfaces not covered with waterproofing from overspray, spilling, or otherwise marring of the surface with the asphalt materials.

Ensure that the edge of any exposed application is sharply defined true to line with a uniform exposure.

Do not apply waterproofing fabric or membranes over attachments and hardware. Seal the discontinuities in waterproofing with Asphalt, 702.06, or hot applied joint sealer, 705.04.

B. Preparation of Surface.

1. Asphalt Materials. Remove concrete projections. Using wire brushes and clear water, remove dirt and the outside film of cement. Before applying asphalt materials, ensure that the concrete is clean and dry and the concrete temperature is at least 40 °F.

2. Membranes. Remove protrusions from the concrete. Sweep off dirt and dust, and blow the concrete clean. Fill joints or cracks greater than 3/8 inch wide with portland cement mortar. In addition to the above, remove oil and grease from surfaces for Type 3 membranes using water and a detergent designed to remove oil and grease from concrete. Flush residual detergent from the surface. Do not allow traffic on the cleaned surface.

C. Primer Coat. Apply the primer coat at the rate of 0.10 to 0.20 gallon of asphalt material per square yard.

For primer coats applied between June 1 and September 1, use asphalt primer for waterproofing or emulsified asphalt primer conforming to 512.02.

For primer coats applied between September 1 and June 1, use asphalt primer for waterproofing conforming to 512.02.

If practical, apply asphalt emulsion using spray equipment.

If subjected to traffic, spread sand on the primer coat for protection. Broom off excess sand before applying asphalt waterproofing.

D. Type A Waterproofing. This type of waterproofing consists of one primer coat and at least two coats of asphalt material conforming to 702.06 to provide a total of at least 1 gallon of asphalt per square yard on flat areas and at least 1/2 gallon per square yard on vertical or sloping surfaces. Start applying the waterproofing at the lowest point, and progress to a higher elevation. Uniformly cover the surface except apply more asphalt in corners and over construction joints. Apply the asphalt material at a temperature from 250 to 350 °F.

E. Type B Waterproofing. This type of waterproofing consists of one primer coat, three coats of asphalt material conforming to 702.06, and two layers of waterproofing fabric conforming to 711.24 applied as follows:

1. On a clean, dry, and well-primed surface, apply a thorough coating of asphalt at a temperature from 250 to 350 °F.

2. Apply the coating at a rate of at least 1/3 gallon per square yard of surface.

3. While the asphalt is hot enough to penetrate the fabric, lay the fabric according to the following:

a. Surfaces Wider than Normal Fabric Strip. For the first strip, lay a half-width [normally 18 inches wide] strip of fabric. For the second strip use a full-width strip of fabric, and lap the entire width of the first strip. Lap each succeeding strip 2 inches more than half its full width. Lap the fabric strips in the direction of water flow.

b. Surfaces with Same Width as Fabric Strip. For the first strip, lay a full-width strip. For the second strip, lay another full-width strip, covering the first.

Lay each strip without wrinkles, folds, or pockets. Thoroughly coat the strip with asphalt for the full width of the lap before laying the succeeding strip. Each application shall entirely conceal the texture of the fabric.

4. Apply a final coat of asphalt to provide a thorough covering for the fabric.

5. For all three coats, use a total of at least 1 gallon of asphalt waterproofing material per square yard.

Lap ends of fabric strips at least 12 inches, and stagger the end joints.

F. Type E Waterproofing. This type of waterproofing consists of a cold applied liquid membrane waterproofing material conforming to 702.08. Apply the coating when the air temperature is 40 ºF or above, on a clean and dry surface, at a rate of 20 to 30 square feet per gallon to achieve a total thickness of 55 to 65 mils. Cover after cured according to the manufacturer's recommendation and within 45 days of application.

G. Type 2 Membrane Waterproofing. This type of waterproofing consists of a rubberized asphalt and peel-and-stick waterproofing membrane 711.25. Follow manufacturer's written recommendations for application of this product. Submit manufacturer's written recommendations to the Engineer. After installing the primer coat, if required, remove the membrane's release liner and place the adhesive side on the prepared concrete surface. Lay the membrane smooth and free of wrinkles. Lap joints in membranes by at least 1 inch. Store membrane materials indoors at temperatures not to exceed 120 °F.

For precast concrete three- and four-sided structures, install Type 2 membrane on the exterior vertical and exterior top horizontal surfaces.

H. Type 3 Membrane Waterproofing. This type of waterproofing consists of a primer coat conforming to 705.04 and a waterproofing membrane consisting of a high density asphalt mastic between two layers of polymeric fabric conforming to 711.29. The application of this product shall follow the manufacturer's written recommendations. Submit manufacturer's written recommendations to the Engineer.

Keep membrane and primer materials dry before installation.

Heat the membrane primer in an oil primer heated, double-jacket kettle. Use a kettle that is clean and free of other materials with any obvious buildup scraped out. The Contractor may use a single-jacket kettle if the primer is capable of being heated in direct fire to the application temperature. Heat primers within the manufacturer's recommended temperatures.

On bridges with curbs, apply the primer and membrane 3 inches up the curb face. On prestressed box beam bridges with no approach slab, apply the primer and membrane 6 inches over the ends of the beams. On prestressed and slab bridges with approach slabs, apply the primer 2 feet out onto the approach slab.

If the plans require a Type 3 membrane on the top exterior surface of precast concrete three- or four-sided structures, apply the primer and membrane to overlay the vertical exterior sides of the structure by 12 inches.

Apply primer no further than 5 feet in front of the membrane using a squeegee to fill all voids and imperfections. Apply membrane from the low to the high side of the surface. Apply an extra bead of primer at the edge of the membrane. Lap joints in membranes by at least 3 inches. After installing the membrane over the entire surface, seal joints in the membrane by applying primer and smoothing with a V-squeegee. If asphalt pavement is to be placed directly over the water proofing membrane, first apply tack coat as specified in Item 407 without damaging the membrane.

512.09 Method of Measurement. The City will measure Waterproofing, of the type specified, by the number of square yards or on a lump sum basis.

The City will measure sealing of concrete surfaces by the number of square yards of coated area projected to a two-dimensional surface.

The City will measure the sealing of concrete bridge decks with HMWM resin and treating concrete bridge decks with SRS as the actual area in square yards of surfaces treated.

The City will measure the actual length in linear feet of crack repaired by epoxy injection.

512.10 Basis of Payment. The City will pay for accepted quantities at the contract prices as follows:

The City will consider the cost for the obtaining and repairing the two cores used by the Engineer to determine the extent of the epoxy penetration as incidental to the work of repairing the concrete by epoxy injection.

The City will consider the removal of dust, dirt, oil, wax, curing compounds, efflorescence, laitance, existing coating, and other foreign materials as incidental to the surface preparation of the concrete surfaces to be sealed.

Item	Unit	Description
512	Square Yard	Sealing of concrete surfaces
512	Square Yard	Sealing of concrete surfaces (non-epoxy)
512	Square Yard	Sealing of concrete surfaces (epoxy urethane)
512	Square Yard	Sealing of concrete bridge decks with HMWM resin
512	Square Yard	Treating concrete bridge decks with SRS
512	Square Yard	Treating concrete bridge decks with Gravity-Fed Resin
512	Foot	Concrete repair by epoxy injection
512	Square Yard, or Lump Sum	Type A Waterproofing
512	Square Yard, or Lump Sum	Type B Waterproofing
512	Square Yard, or Lump Sum	Type E Waterproofing
512	Square Yard, or Lump Sum	Type 2 Waterproofing
512	Square Yard, or Lump Sum	Type 3 Waterproofing

ITEM 513 STRUCTURAL STEEL MEMBERS

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513.29 Method of Measurement
513.30 Basis of Payment

513.01 Description. This work consists of preparing shop drawings, furnishing and fabricating structural steel members, nondestructive testing, fabricator performed quality control, documentation, cleaning, shop coating, and erecting structural steel and other structural metals. Prepare shop drawings and erect structural steel according to Item 501 and the additional requirements below. Shop painting shall conform to Item 514. The work also includes any work to move existing steel structures to the plan location, making necessary repairs and alterations, and connecting or joining new and old construction.

The terms "main," "secondary," or "detail," as referred to in Item 513, are defined as follows: "main" refers to material, members, and fasteners that are primarily stressed by live load and structure weight; "secondary" refers to material, members, and fasteners that do not directly support live load or main members; "detail" refers to essential non-structural material, members, and fasteners.

513.02 Fabricator Approval Procedure. Select fabricators that are listed by ODOT before the Contract letting date as evaluated by the Laboratory and pre-qualified according to ODOT Supplement 1078.

The Laboratory may accept subletting of processes that require specialized machinery or knowledge. Submit written requests for subletting to the Laboratory. The Laboratory will determine if the process is uncommon and will evaluate the qualifications of the proposed sublet fabricator. The fabricator's quality control staff shall witness and perform quality control of the sublet work.

513.03 Levels of Fabricator Qualification. There are eight levels of fabricator qualification. The Laboratory will classify each fabricator at the highest level of fabrication it is qualified to perform.

Level	Description of Capabilities
SF	Standard fabricated members described and paid for as Item 516, 517, and 518 and detailed by standard bridge drawings. Material and fabrication acceptance by certification with random City audits of the work and documentation.
UF	Unique fabricated members not covered by standard bridge drawings and not designed to carry tension live load. Examples include curb plates, bearings, expansion joints, railings, catwalk, inspection access, special drainage, or other products. Examples also include retrofit cross frames, retrofit gusset plates, retrofit lateral bracing, or other miscellaneous structural members not included in Levels 1 through 6. Quality assurance of shop drawings, material test reports, and inspection according to ODOT Supplement 1078.
1	Single span, straight, rolled beam bridges without stiffeners, Secondary and Detail materials designed to carry tension live loads such as retrofit moment plates. Case II Loading. Quality assurance of shop drawings, material test reports, and inspection according to ODOT Supplement 1078.
2	Multiple span, straight, rolled beam bridges without stiffeners. Case II loading. Quality assurance of shop drawings, material test reports, and inspection according to ODOT Supplement 1078.
3	Single or multiple span, straight, dog legged, or curved, rolled beam bridges including stiffeners. Case I or II Loading. Quality assurance of shop drawings, material test reports, and inspection according to ODOT Supplement 1078.
4	Straight or bent welded plate girder bridges. Case I or II loading. Quality assurance of shop drawings, material test reports, and inspection according to ODOT Supplement 1078.
5	Straight, curved, haunched, or tapered welded plate girder bridges. Case I or II loading. Quality assurance of shop drawings, material test reports, and inspection according to ODOT Supplement 1078.
6	Truss bridges, fracture critical bridges, fracture critical members, or fracture critical components new or retrofitted. Case I or II loading. Quality assurance of shop drawings, material test reports, and inspection according to ODOT Supplement 1078.

513.04 General. Perform all steel fabrication including the shop application of coatings in a prequalified structural steel fabricating shop consisting of adequately sized permanent buildings with equipment, heat and light, and experienced personnel to satisfactorily perform all necessary operations. Perform flame cutting, air carbon-arc gouging, cambering, welding, cleaning, and painting inside permanent buildings that are maintained at the required environmental conditions. The fabricator may perform shop assembly of large pieces for fit-up of field connections outdoors. These provisions will not apply to steel requiring fabrication at the bridge site in the repair, alteration or extension of an existing structure.

If repairing, extending, or altering existing structures, take measurements of the existing structure as required to accurately join old and new work. Include these measurements on shop drawings. Measurements shown on the plans that indicate the extent and nature of repair, alterations or extension shall not relieve the Contractor of this responsibility.

At least two weeks before starting shop fabrication, the fabricator shall notify the Engineer and furnish a proposed fabrication schedule for the work.

Unless the Engineer provides a written waiver of a hold or witness point inspection, the fabricator shall store members completed during the inspector's absence in a manner that allows the inspector to completely and safely inspect the finished work.

The fabricator shall not ship fabricated members performed under Item 513, UF Level or Levels 1 through 6 from the shop without prior hold point inspections unless the Engineer waives the inspection. The Engineer will not conduct the scheduled final inspection until the fabricator completes and inspects with documentation, final fabrication and shop coatings and the Contractor documents approval of shop drawings and material test reports.

The Engineer will not conduct a final fabrication inspection of SF Level members. Instead, the Engineer will conduct random inspections during the fabricator's work.

The fabricator shall provide an office with the following attributes:

A. A minimum floor area of 120 square feet.

B. A minimum ceiling height of 7 feet.

C. Adequate working and storage facilities with one locking file cabinet for the exclusive use of the City's inspector, lighting, and electrical outlets.

D. Provisions for heating to a minimum temperature of 68 °F and adequately ventilated.

E. A telephone with direct access to an outside trunk line for the exclusive use of the inspector.

If using steel stamps for identification purposes, use the "mini-stress" or "stressless" type.

513.05 Fabricator Documentation Responsibility. The fabricator shall keep and maintain documentation records as specified in ODOT Supplement 1078.

At the City's request, provide access to the above documents for audit, inspection, and copying.

513.06 Shop Drawings. Provide shop drawings conforming to 501.04 and the following requirements:

Include details, dimensions, size of materials, match mark diagrams for field connections, a diagram identifying, by some unique mark, each area of a welded splice to be covered by a single radiograph, and other information necessary for the complete fabrication and erection of the metal work.

For multiple span beam and girder bridges, include an overall layout with dimensions showing the relative unloaded vertical and horizontal position of beam or girder segments with respect to a full length base or work line. Account for camber and horizontal curvature of the beams or girders, and the effect of deck surface profile in this layout. Show required offsets for vertical and horizontal curvature at approximately each one-fourth of span length, at field splices, and at bearing points. For horizontally curved members, show the offset to a baseline strung from end to end of the member, every 10 feet of length.

Identify the grade (ASTM designation), CVN, fracture critical, or any special testing requirements for each piece of steel. Identify pieces made of different grades of steel with different assembling or erecting marks, even if the pieces have identical dimensions and detail.

Identify the welding procedure by the WPS number at each joint and the location and identification numbers of all radiograph tests.

Detail structural steel to fit under full steel dead load and prior to deck placement with the webs of primary members plumb.

513.07 Levels 1 through 6, Prefabrication Meeting. After providing the notice and schedule required by 513.04 and at least 3 days after the City receives shop drawings, conduct a prefabrication meeting at the fabricator's facilities, or another location agreed to by all parties. The fabricator and its quality control specialists for fabrication and painting, the inspector, and the Contractor, or its designated representative, shall attend the meeting. The purpose of this meeting is to review any fabrication issues, including information on shop drawings, inspection, hold or witness points, unique fabrication items, special processes, and both the fabrication and project schedule. The fabrication quality control specialist shall conduct the meeting and record and distribute meeting minutes that document all issues discussed. Fabrication may begin after the prefabrication meeting is complete.

513.08 Materials. Furnish materials conforming to 501.06.

513.09 Material Control. Identify and mark each piece of steel according to the shop drawings and the following requirements.

Immediately after removing steel that is furnished in tagged lifts or bundles, mark the individual pieces of steel with the ASTM A 6/A 6M specification identification color code and heat number.

The fabricator may furnish material from stock that is marked with the heat number and mill test report.

If separated from the full-size piece furnished by the supplier, mark excess material placed in stock for later use with the heat number and, if provided, with the ASTM A 6/A 6M specification identification color code.

During fabrication, clearly and legibly mark the specification identification color code and heat number on each piece of steel.

Before cutting steel into smaller size pieces, clearly and legibly mark each smaller size piece with the ASTM A 6/A 6M specification identification color code and heat number.

Unless otherwise approved by the inspector, mark pieces of steel that will be subject to fabricating operations such as blast cleaning, galvanizing, heating for forming, or other operations that may obliterate paint color code and heat number markings with steel stamps or with a substantial tag firmly attached to the piece of steel. At locations acceptable to the Engineer, stamp the heat numbers into main material tested for CVN.

Issue cutting instructions by cross-referencing the assembly marks shown on the shop drawings with the corresponding item covered on the mill purchase order. The fabricator's system of assembly-marking individual pieces of steel and issuing cutting instructions shall provide a direct reference to the appropriate mill test report.

The fabrication quality control specialist shall provide the Engineer with a letter documenting that the fabricator performed material control according to this specification.

513.10 Care of Material. Store structural material at the shop or field above the ground, upon platforms, skids, or other supports. Use straight structural steel with clean and dry surfaces before working it in the shop. Before using, clean all rusted or corroded material. Only use this material if it conforms to ASTM A 6/A 6M thickness tolerances after cleaning.

513.11 Workmanship and Straightening. If necessary to straighten rolled material, use methods that will not damage the member. If carefully planned and supervised, apply localized heat for straightening. Do not allow the temperature of the heated area to exceed 1150 °F as controlled by pyrometric stick or thermometers. Do not quench to accelerate cooling. Do not kink or offset the material if using mechanic or hydraulic force to camber or strengthen material. Do not cold bend fracture critical materials.

Camber rolled beams as shown on the plans in the prequalified fabricating shop using heat or hydraulic jacks. Control heating as specified above and follow a formal shop heating procedure. Camber plate girders by trimming web plates before assembly. During fabrication, shipping, and erection, support and handle members to maintain camber.

Fabricate structural steel to within the dimensional tolerances specified by Articles 3.5 of the AASHTO/AWS *Bridge Welding Code*, with the following modifications:

A. Waviness, the deviation of the top or bottom surface of a flange from a straight line or plan curvature, shall not exceed 1/8 inch when the number of waves in a 10-foot length is four or less, or 1/16 inch when more than four, but sharp kinks or bends shall be cause for rejection.

B. For the measurement of camber during lay down, position the bearing points both horizontally and vertically to plan dimensions ±1/8 inch.

C. Measure camber as the vertical offset between the steel and the common base line extending from abutment bearing to abutment bearing. The maximum camber tolerance at mid-span shall be 0 inch and the greater of +3/4 inch or the designed haunch height. Prorate the maximum camber tolerance at mid-span between the center of the span and each adjacent bearing to provide a smooth unbroken curve.

D. Permissible difference in horizontal curvature of top and bottom flange at any point on centerline of member, when measured as specified in 3.5.1.4, shall not exceed 3/8 inch.

513.12 Finish. Plane sheared edges of all main material to a minimum depth of 1/4 inch except for ASTM A 709/A 709M, Grade 36 steel having a thickness of 5/8 inch or less. Remove fins, tears, slivers, and burred or sharp edges from steel members by grinding. If these conditions appear during the blasting operation, re-grind and re-blast the steel members to the required surface profile.

The fabricator may flame cut structural steel. Provide a smooth surface, free from cracks and notches, and use a mechanical guide to provide an accurate profile. Roll and flame cut surfaces according to the AASHTO/AWS *Bridge Welding Code*, as amended by ODOT Supplement 1011.

Provide a surface finish for bearing and base plates and other bearing surfaces that contact each other or concrete according to ANSI B46.1, Surface Roughness, Waviness and Lay, Part I.

ANSI B46.1

Steel slabs	2000 mil
Heavy plates in contact in shoes to be welded	1000 mil
Milled ends of compression members, milled or ground ends of stiffeners and fillers	500 mil
Bridge rollers and rockers	250 mil
Pins and pin holes	125 mil
Sliding bearings	125 mil

513.13 Stiffeners. Place the bearing end of bearing stiffeners flush and square with the web and in a manner so at least 75 percent of the area of the bearing end is in contact with the inner surface of the flange. The other end of the bearing stiffener shall have a tight fit as defined below. Position bearing stiffeners to be vertical after erection. Weld intermediate stiffeners that are not used in pairs to the compression flange, and provide a tight fit for the tension flange. Weld intermediate stiffeners connected to cross frame angles to the top and bottom flange.

A tight fit is defined as the contact between the stiffener and flange over some portion of the end of the stiffener and having no gap greater than 1/16 inch.

Clip stiffeners 2 1/2 inches along the web and 1 inch along the flange to clear flange-web welds and fillet or rolled shapes.

When attaching stiffeners to the web and flanges, do not extend welds to the edge of the stiffeners or into the clip area. Terminate these welds 1/4 ± 1/8 inch at the flange connections and 1/2 ± 1/4 inch at the web connection.

513.14 Fillers. Detail the shop drawings to show fill plates that compensate for the misalignment of abutting elements due to differences in thickness of flanges and webs at the splice locations. Detail the fill plates to the nearest 1/16 inch in thickness, but not less than 1/8 inch thick. However, in the final shop assembly, furnish fills of sufficient thickness to compensate for misalignment of abutting elements due to standard rolling mill tolerances or due to differences in thicknesses of flanges and webs at the splice location. The actual fills used shall compensate for differences in total thickness or relative positions of more than 1/16 inch but with no fills less than 1/8 inch thick. Provide fill plates in bolted joints that are flush with the perimeter of the splice plates.

513.15 Horizontally Curved Beams and Girders. If members are to be heat curved, submit the detailed procedure, including necessary calculations, to the Engineer. Obtain the Engineer's acceptance of the procedure before starting this work.

Curve beams and girders using heat according to *AASHTO Standard Specifications for Highway Bridges*, except that the fabricator may cut flanges for girders to obtain the required alignment.

513.16 Joints and Splices. In bolted construction where tension or flexural members are spliced, maintain a clearance of not more than 1/4 inch between the abutting surfaces of spliced members. For spliced compression members, face the abutting surfaces to provide a uniform bearing when properly aligned and completely bolted.

In welded construction, prepare abutting surfaces as shown on the shop drawings. Verify the preparation for field welded butt joints in main members by a complete shop assembly according to 513.24.

513.17 Pin Holes. Bore pin holes after the member is fabricated and true to size, at right angles to the axis of the member and parallel to each other. Pin holes for up to 5-inch diameter pins shall not exceed the pin diameter by more than 0.020 inch and pin holes for larger pins shall not exceed the pin diameter by more than 0.031 inch.

513.18 Pins and Rollers. Use pins and rollers made from cold rolled steel, accurately turned to size, straight and smooth, and entirely free from flaws. Pins over 9 inches in diameter shall be annealed. In pins larger than 9 inches in diameter, bore a hole not less than 2 inches in diameter the full length of the axis. Furnish one pilot and one driving nut for each size of pin.

513.19 Holes for High-Strength Bolts and Bearing Bolts. Provide cylindrical holes, perpendicular to the member, clean cut, and free of ragged edges. Remove burrs by countersinking not more than 1/16 inch or by grinding. Provide finished holes with a diameter not larger than the nominal diameter of the bolt plus 1/16 inch. The hole diameter shall not vary by more than 1/32 inch from a true circle for 85 percent of the holes in a contiguous group, and not more than 1/16 inch for the remainder.

Punch holes using a die with a diameter not exceeding that of the punch by more than 1/16 inch. Ream and drill holes using twist drills and twist reamers. Wherever possible, direct the reamer by mechanical means.

Sub-drill holes 3/16 inch less in diameter than the nominal diameter of the bolt, and ream the holes to size with the parts assembled, except:

A. The fabricator may sub-punch main material conforming to ASTM A 709/A 709M, Grade 36 steel that is less than 3/4 inch thick, and Grade 50 or 50W steel that is less than 5/8 inch thick.

B. The fabricator may drill full-size holes in materials assembled and adequately clamped together.

C. The fabricator may punch full-size holes in secondary and detail material conforming to ASTM A 709/A 709M, Grade 36 steel that is less than 3/4 inch thick, and Grade 50 or 50Wsteel that is less than 5/8 inch thick.

D. The fabricator may make assemblies such as floor beams connected to girders and rolled beam spans connected by diaphragms through steel templates.

Place all sub-punched or sub-drilled holes with sufficient accuracy such that after assembling (before reaming) a cylindrical pin 1/8 inch smaller than the nominal size of the punched hole may be entered perpendicular to the face of the member without drifting in not less than 75 percent of the contiguous holes in the same plane. All holes shall allow a pin 3/16 inch smaller than the nominal size of the punched holes to be inserted in the above manner.

Do not plug located holes without written approval from the Engineer.

Provide steel templates with hardened bushings in holes that are accurately located in relation to the centerline of the connection as inscribed on the template. The fabricator is not required to use hardened bushings when using a roto-broach, shell drill, or other similar tool, to make the holes.

Ream and drill holes through multiple piles only if the plies of the joint are held tightly together with bolts or clamps and if sub-punched or sub-drilled, only if the joint is pinned. Disassemble and clean the piles of burrs and shavings before final assembly.

The Contractor may drill or punch bolt holes full sized in unassembled pieces or connections, including templates for use with matching sub-sized and reamed holes, using suitable numerically controlled (N/C) drilling or punching equipment. If using N/C drilling or punching equipment, demonstrate the accuracy of the drilling or punching procedure to the inspector according to 513.24.

After holes are reamed or drilled full size, 85 percent of the holes in any contiguous groups shall have no offset greater than 1/32 inch between adjacent plies. The remainder of the holes shall not be offset more than 1/16 inch between adjacent plies.

If requested in writing, the Engineer may consider other methods of preparing holes for high-strength bolts.

513.20 High-Strength Steel Bolts, Nuts, and Washers. Provide high-strength steel bolts, nuts, and washers conforming for all bolted connections including erection bolts for cross frames and lateral bracing to 711.09.

A. General. Provide the Engineer with access to the work for observing the installation and the tightening and checking of the bolts.

Determine the required bolt length by adding the value from Table 513.20-1 to the grip. The table values include an allowance for manufacturing tolerances and provide a bolt length for threads to protrude through the nut. Add 5/32 inch for each hardened flat washer used and 5/16 inch for each beveled washer used. Adjust the length, as determined by Table 513.20-1, to the next longer 1/4 inch; when installed, the end of the bolt shall be flush with or project several thread lengths outside the face of the nut.

TABLE 513.20-1

Bolt Size (inches)	To determine required bolt length, add to grip [1] (inches)
1/2	11/16
5/8	7/8
3/4	1
7/8	1 1/8
1	1 1/4
1 1/8	1 1/2
1 1/4	1 5/8
1 3/8	1 3/4
1 1/2	1 7/8
[1] Total thickness of all connected material excluding washers.	

Use bolts, nuts, and washers with a residual coating of lubricant when received. Bolts, nuts, and washers without their original lubrication shall not be used.

B. Preparation. With the exception of metalizing, galvanizing, and both organic zinc and inorganic zinc primers, remove coatings from joint surfaces, including surfaces adjacent to the bolt heads, nuts, and washers. Remove lacquer, dirt, oil, loose scale, rust, burrs, pits, and other substances or defects that prevent solid seating of the parts or interfere with the development of complete frictional contact. Do not place gaskets or other yielding material between joint surfaces.

C. Installation. For each bolt, place a hardened washer under the element (nut or bolt head) turned in tightening. If an outer face of the bolted parts has a slope of more than 1:20 with respect to a plane normal to the bolt axis, use a smooth beveled washer to compensate for the lack of parallelism.

If necessary, the Contractor may clip washers, at one location, not closer than seven-eighths of the bolt diameter from the center of the washer.

During final assembly of the parts to be bolted, first install a sufficient number of drift pins to provide and maintain accurate alignment of holes and parts, then a sufficient number of bolts tightened to a snug tight condition to bring all the parts of the joint into complete contact. Replace any bolts that were installed before installing drift pins. Before releasing the member from the hoisting equipment, fill half the holes with drift pins and bolts tightened to a snug tight condition in at least 50 percent of the holes (preferably, half pins and half bolts) but use at least two drift pines in each flange and web of each beam or girder. Install bolts starting at the most rigidly fixed or stiffest point and progress toward the free edges.

Use cylindrical drift pines that are not more than 1/32 inch smaller than the hole diameter.

Bolts are snug tight when an impact wrench begins to impact the nut or when a man applies full effort using an ordinary spud wrench.

Install bolts in the remaining open holes and tighten the bolts to a snug tight fit, after which all bolts shall be tightened completely by the turn-of-nut method.

Where difficulty is experienced with the fit of the connection and the bolts are used to draw the elements into contact, check all bolts in the affected portion of the connection for a sustained snug tight condition.

Replace drift pins with completely tightened bolts only after all the remaining holes are filled with completely tightened bolts.

Do not field ream holes drilled full size during fabrication.

After bolts are snug tight, the wrench operator shall match-mark the outer face of the nut with the flush or protruding portion of the bolt using a crayon or paint. The Engineer will use the match-marks to determine the relative rotation between the bolt and nut during final tightening using the turn-of-the-nut method.

Commence tightening at the most rigidly fixed or stiffest point and progress toward the free edges, both in the initial snugging up and in the final tightening. If required because of wrench operation clearances, tightening may be done by turning the bolt. If used, provide impact wrenches of adequate capacity to perform the required tightening each bolt in approximately 10 seconds.

Do not reuse galvanized A 325 bolts. Re-tightening previously tightened bolts that became loose by tightening adjacent bolts is not reuse.

Follow the additional bolting requirements in 513.26.

D. Bolt Tension. When all bolts in the joint are tight, the minimum bolt tension for each bolt size is shown in Table 513.20-2.

TABLE 513.20-2

Bolt Size (inches)	Bolt Tension [1] (kips), minimum A 325
1/2	12
5/8	19
3/4	28
7/8	39
1	51
1 1/8	56
1 1/4	71
1 3/8	85
1 1/2	103

[1] Equal to 70 percent of specified minimum tensile strengths of bolts, rounded off to the nearest kip.

TABLE 513.20-3 NUT ROTATION FROM SNUG TIGHT CONDITION

Bolt Length (as measured from underside of head to extreme end of point)	**Disposition of Outer Faces of Bolted Parts**		
	Both faces normal to bolt axis	One face normal to bolt axis and other face sloped not more than 1:20 (bevel washer not used)	Both faces sloped not more than 1:20 from normal to bolt axis (bevel washer not used)
Up to and including 4 diameters	1/3 turn	1/2 turn	2/3 turn
Over 4 diameters but not exceeding 8 diameters	1/2 turn	2/3 turn	5/6 turn
Over 8 diameters but not exceeding 12 diameters	2/3 turn	5/6 turn	1 turn

Attain the bolt tension specified in Table 513.20-2 by tightening all bolts, the applicable amount of nut rotation specified in Table 513.20-3 by the turn-of-nut method.

Nut rotation is relative to bolt, regardless of the element (nut or bolt) being turned. Tighten bolts requiring 1/2 turn and less within ±30 degrees and tighten bolts requiring 2/3 turn and more within ±45 degrees.

E. Inspection.

1. The Engineer will inspect the first completed connection of each bridge according to 513.20.E.2 below and subsequent connections the Engineer deems necessary. Thereafter, where the Engineer has approved the joint compactness and snug-tight condition of bolts prior to bolt tightening by the turn-of-nut method, the bolt tension as required in Table 513.20-2 shall be considered as attained if the amount of nut rotation specified by Table 513.20-3 is verified by the required match-marking.

2. Furnish and use manual torque wrenches to inspect bolts. Perform test to the satisfaction of the Engineer. Calibrate the inspection torque wrenches at least once each workday using a device, approved by the Engineer, and capable of indicating bolt tension. Use three bolts, placed and tensioned individually, representative of the grade, size, length, and condition used in the structure to determine the job inspection torque according to 513.20.E.3. Place a washer under the part being turned.

3. Tighten each of the three representative bolts, using any convenient manner, to the tension shown in Table 513.20-2. Then, using the inspection wrench, apply a slow steady pull to the tightened bolt and measure the torque required to turn the nut or head 5 degrees, approximately 1 inch at a 12-inch radius in the tightening direction. Use the average torque measured in the tensioning of the three bolts as the job inspection torque.

4. With the Engineer present, randomly select for inspection two bolts or 10 percent of the bolts, whichever is greater, from each connection represented by the 3-bolt sample described in 513.20.E.2. Using the inspection wrench, apply the job inspection torque in the tightening direction. The Engineer will accept the connection if the job inspection torque does not turn the nut or bolt head. If the job inspection torque turns a nut or bolt head, apply the job inspection torque to all the bolts in the connection and reinspect the connection as described above.

F. Calibration Devices. The manufacturer of the calibration device or a qualified testing laboratory shall periodically examine each calibration device at least once each year and other times if requested by the Engineer. After calibration, the manufacturer or testing laboratory shall certify that each calibration device accurately indicates the actual bolt tension.

513.21 Welding. Perform welding by the shielded metal-arc, submerged arc, flux cored arc, or stud welding process. Only shielded metal arc (stick) welding is prequalified. All other welding processes require testing and approval by the Engineer. Consideration will be given to other methods of metal-arc welding if a written request is submitted to the Engineer.

In other respects, the AASHTO/AWS *Bridge Welding Code*, as amended by ODOT Supplement 1011, shall govern the work.

Post copies of the shop welding procedures at each welding location.

Weld only fracture critical and main members when the fabrication quality control specialist and inspectors are physically at the facility. The fabricator shall not perform fracture critical welding without prior scheduling with the fabrication quality control specialist and the inspector. The fabrication quality control specialist shall witness the minimum percentages specified in ODOT Supplement 1078 and shall check all welding processes.

For non-fracture critical welds, the fabrication quality control specialist shall perform frequent inspections, and check all welding processes.

513.22 Stud Shear Connectors. Perform stud welding according to the AASHTO/AWS Bridge Welding Code, as amended by ODOT Supplement 1011, and this subsection.

In addition to the stud bend tests of Article 7.6.6.1 of the AASHTO/AWS Bridge Welding Code, perform bend tests of stud shear connectors at the start of each workday, when welding has been interrupted for an hour or more, when changing grounds, when changing weld settings, and when changing cable loop due to arc blow. Do not weld more than 500 studs without the welds being field bend tested in accordance with the specified procedure. The Contractor may leave in the bent position tested studs that show no sign of failure, as determined by the Engineer.

Weld stud shear connectors to the top flanges of beams or girders after the steel has been erected and suitable scaffolding or deck forming has been provided. Studs may be welded to beam or girder webs, end dams, bearing plates, or to other secondary members and detail material in the shop. For galvanized structures with welded shear connectors, remove the galvanic coating by grinding at each connector prior to welding.

513.23 Threads for Bolts and Pins. Threads for pins shall conform to the Unified Standard Series ANSI B1.1-UNC (ANSI B1.13M) Class 2A for external threads and Class 2B for internal threads, except that pin ends having a diameter of 1 3/8 inches or more shall be threaded 6 threads to the inch.

513.24 Shop Assembly. Remove paint, grease, oil, rust, loose mill scale, and protruding edges or burrs from all contact surfaces. Unless waived by the Engineer, do not assemble and weld flanges and webs to form girders or other similar members and do not accomplish fabrication or assembly that interferes with the repair of a butt weld until the fabrication quality control specialist for the A rated fabricators or the inspector for B and C rated fabricators examines and approves radiographs of all butt welds in the component parts.

Perform fit-up work with the members assembled in unloaded positions as shown on the shop drawing layout required by 513.06. During shop assembly, adequately support members, especially at joints, to prevent misalignment or deflection and designate supports that prevent settlement during the fit-up, reaming or drilling of connections. The fabrication quality control specialist shall maintain records of the actual horizontal and vertical dimensions and relative positions of each assembly for each offset required by 513.06 and, upon request, furnish a copy to the inspector. Reposition members that become a part of two assemblies for the second assembly to the dimensions recorded for the first assembly.

Using steel stamps, match-mark all connecting parts assembled in the shop for the purpose of reaming or drilling of holes for field connections or for fit-up of field welded connections before disassembly. Punch mark bearing centerlines.

Continuous beam and plate girders, including sections adjacent to hinged, pin connected, sliding, or rocker bearing joints, shall have at least three adjacent segments assembled, and holes reamed or drilled while assembled. Check the fit-up of field welded connections by similar shop assembly.

Shop assemble longitudinal or transverse beams and girders that are either framed or connected by diaphragms and floor beams to check fit-up of connections to be field welded, or to ream or drill holes for bolted connections. Assemble trusses in lengths of at least three abutting panels before drilling or reaming field connections.

Include deck plates in the final shop assembly of bridges that involve railroad deck plates, even if welding of these deck plates takes place in the field.

If the fabricator elects to use numerically controlled drilling or punching, the required assembly shall be performed as specified above. The Engineer will consider the Contractor's written request to use other methods of checking hole alignment and match marking. If the Engineer does not consider, or disapproves the fabricator's proposed methods of assembly, perform the work according to 513.19 and 513.24.

After fabrication, shop assemble deck expansion devices to check fit-up, straightness, and roadway cross-slope changes. Full width assembly is required with phased construction if expansion devices have interlocking fingers or have mechanical devices that require exact field alignment.

The fabricator may fabricate part-width deck segments without the required shop assembly under the following conditions:

A. The plans require a phased construction sequence.

B. Shop drawings incorporate a lay down, similar to 513.06, defining vertical offset dimensions from a full length common baseline to all roadway changes including sidewalks, rounding, crowns, and field splice points of the expansion device.

Secure parts not completely assembled in the shop with temporary bolts to prevent damage in handling and shipping. In the shop, bolt field splice plates into final position shift the splice plates laterally with respect to their final position so that the ends of the plates are flush with the ends of the member. Without the Engineer's written acceptance, do not weld or tack-weld to bolted assemblies. Perform authorized welding according to 513.21.

513.25 Nondestructive Testing. Nondestructive testing shall conform to the AASHTO/AWS *Bridge Welding Code*, as amended by ODOT Supplement 1011 and as specified below.

As the Engineer directs, perform ultrasonic or radiographic inspection of field welded repairs in main members for thick scabs, deep kerfs or nicks, and similar gross flaws. Ensure that all examined welds and base metal adjacent to a welded joint conform to the quality requirements specified in 513.21. Submit radiographs, field sketches showing specific locations, lengths and depths of the repair, and two copies of the radiographic or ultrasonic technical reports to the Engineer for acceptance. Receive the Engineer's acceptance before performing construction activities making welds inaccessible for repair.

The Contractor or fabricator shall notify the City at least 48 hours before performing nondestructive testing. Provide this notice even if specific hold or witness point inspections are not required by ODOT Supplement 1078.

The Engineer has the final authority to accept welds and will resolve controversies regarding the interpretation of radiographs, magnetic particle indications, or the acceptability of welds.

A. Radiographic Inspection of Welds. Before inspection, grind welds smooth. Grind web splices only where radiographed, except grind outside fascia surfaces the full length. Inspect the following welds:

1. The full length of all butt welds in flange material of plate girders or rolled beams. One hundred percent of butt welds in back up bars that remain in the structure.

2. The top and bottom one-third of transverse web splices in plate girders or rolled beams and show any cope holes. If an unacceptable weld occurs, radiograph an adjoining 12-inch length of weld not previously inspected. If unacceptable flaws are found in this adjoining segment, radiograph the remainder of the weld.

3. Butt welds in longitudinal stiffeners attached to tension areas of webs.

4. Twenty-five percent of each longitudinal web splice as selected by the inspector.

5. Full length of field flange cut repairs.

6. Other welds specified in the Contract or AASHTO/AWS *Bridge Welding Code*.

Use a steel stamp to make the radiograph identification mark shown on the shop drawing layout in the area marked "Weld Identification" of Figures 6.1A through 6.1D of the AASHTO/AWS *Bridge Welding Code* in a manner to make it visible in the radiograph of the area without resorting to superimposed like markings. Place steel stamped identification marks on flange plates so that after girder assembly the marks are on the inside of flange and outside the area fastened to the web. Identify films of repaired welds by the letter "R". Do not place steel stamped identification numbers within the weld area. Use superimposed characters to make other required markings.

Use film locations or a technique employed that will show the top and bottom images of the plate edge. Use films 4 1/2 × 17 inches where practical and a minimum film size of 4 1/2 × 10 inches.

Supply a technical report for the RT testing similar to Annex III Form III-5 of the AASHTO/AWS *Bridge Welding Code*, and include the following: Project identification, member piece mark, description of the repairs made, and the qualification level of the technician.

The City will take ownership of contact films. For main material repairs, provide sketches that clearly show specific locations, lengths and depths of field cuts, or damages repaired by field welding.

B. Magnetic Particle Inspection of Welds. Before magnetic particle inspection (MPI), complete welding required to fabricate each beam or girder, correct all visual defects, and clean the weld. If the fabricator's quality control plan is acceptable to the City and additional processing does not produce a potential for cracking, the City may allow the Contractor to perform MPI before complete welding.

Inspect welds using the procedure and techniques for the dry powder magnetic-particle examination of welds using the prod or the yoke method according to AWS 6.7.6. The prod test equipment shall have a functioning ammeter. Provide a prod magnetizing current of 100 amperes per inch of prod spacing but not less than 400 amperes. Use only aluminum prods.

Inspect at least 1 foot for every 10 feet, or fraction thereof, for each size of weld in the following:

1. Flange-to-web welds, including ends of girder after trimming.

2. Moment plate to flange welds.

3. Bearing stiffener welds.

4. Other welds specified in the Contract or AASHTO/AWS *Bridge Welding Code*.

5. Field weld repairs as directed by the Engineer.

The inspector or the fabrication quality control specialist will select random test sections. Unless waived by the Engineer, the inspector will observe inspection by C-rated fabricators. Position test sections as necessary for the inspection and after considering the safety and convenience to the inspecting personnel.

If a test section contains unacceptable defects, test 5-foot segments on both sides of the test section, or, if less than 5-foot segments are on both sides of the test section, test the full length of the weld. Retest welds requiring repair after repairs are complete. MPI will not locate all surface defects of Article 9.21 of the AASHTO/AWS *Bridge Welding Code*. Unacceptable welds have MPI results that indicate defects exceed the above quality standards.

For each unacceptable defect, the fabricator shall record the piece mark, the location of the defect on the member, the defect description, and the proposed repairs.

C. Ultrasonic Testing of Welds. Perform ultrasonic inspection of the following welds:

1. Complete joint penetration flange-to-web, T, or corner joint welds: 25 percent for non-FCM, 25 percent compression or shear FCM, and 100 percent tension FCM.

2. Complete penetration butt welds: 100 percent tension FCM and 25 percent compression FCM.

3. Other welds: as specified in the Contract or AASHTO/AWS *Bridge Welding Code*.

The fabrication quality control specialist shall provide the Engineer with specified certification, sketches, technician reports, and a letter documenting that the Contractor performed nondestructive testing according to this specification.

513.26 Shipping, Storage, and Erection. Repair or replace, at the discretion of the Engineer, members damaged by improper handling, storing, or erection.

During transportation, place adequate blocking between members to prevent movement and facilitate unloading. Unless reinforced by additional plates, angles, or other material bolted in place, do not use field connection holes for tie-down. Band together bearing components.

Place material stored in the fabricating shop or in the field on skids or blocks to prevent the metal from contacting the ground. Place and shore girders and beams in an upright position for shipping, and field and shop storage. Field splice plates shall be bolted with temporary bolts, which shall be removed and replaced, when field splice plated are placed in their final position or shifted laterally with respect to their final position. Keep material clean and properly drained. Install bearing devices and anchorages according to Item 516.

Thoroughly clean bearing surfaces and surfaces to be in permanent contact before the members are assembled in the field.

Before erecting structural steel, completely bolt up field splices and connections that started before steel erection.

During erection, the Engineer will allow drifting to draw the parts into position, but do not enlarge the holes or distort the metal. Install drift pins and bolts according to 513.20. Fill at least three-fourths of the holes with completely tightened bolts in splices and connections subject to construction loads during erection. Complete permanent fastening of steel truss tension chord members before removing falsework. Permanently fasten compression chord members after the span is released sufficiently from the falsework to bring the compression chord joints into full bearing. Properly regulate and maintain elevations of panel points and ends of floor beams until the falsework is removed.

Do not enlarge the holes of splices and connections between segments or elements of main members without approval by the Engineer.

Adjust structures to the correct alignment and to the marked bearing centerlines before beginning permanent fastening. Do not permanently fasten cross frames and lateral bracing in continuous beam or girder spans until completing main connections in adjacent spans; however, install sufficient bracing to maintain structural stability. For erection bolts used to fasten cross frames, use not less than 5/8-inch diameter, and fully tighten bolts according to 513.20.

Erect end cross frames and end dams in a manner that ensures bearing parts remain in bearing contact.

Permanently fasten all intermediate cross frames before deck placement begins.

The webs of primary members shall be plumb before deck placement begins.

513.27 Shop Coating. For steel surfaces specified to be coated according to Item 514, apply a prime coat in the shop.

513.28 Cleaning ASTM A 709, Grade 50W Steel. Before the new steel is shipped, solvent clean, where necessary, all surfaces of ASTM A 709, and Grade 50W steel that are to be left unpainted to remove all traces of asphalt cement, oil, grease, diesel fuel deposits, chalk, paint marks, and other soluble contaminants according to SSPC-SP 1 Solvent Cleaning. QCP #1 and QCP #2 shall apply according to Item 514.

Shop blast unpainted Grade 50W material to SSPC-SP 6, commercial blast. QCP #3 shall apply according to Item 514.

After placing superstructure concrete, clean, where necessary, the exterior surface and bottom flanges of all fascia beams or girders that are to be left unpainted to remove all traces of asphalt cement, oil, grease, diesel fuel or petroleum deposits, concrete, and other contaminants.

Do not use acid for cleaning.

513.29 Method of Measurement. The City will measure Structural Steel Members on a lump sum basis or by the number of pounds.

If payment is per pound, submit weight computations to the Engineer based upon the accepted shop drawings. Deduct waste material, removed by burning, cutting, machining, holes, etc., but include groove weld bevels. Include the weight of all permanent fasteners, shop fillet welds, other metals and preformed bearing pads. Exclude the weight of paint or galvanized coatings. Exclude thickness or weight of members exceeding the plan requirements (due to overweight or other cause), unless authorized by the City. As an option, measure and record the weight of structural members before painting in the presence of the inspector. Use the following unit weights for computations.

	lb/ft³
Steel cast steel, and deposited weld metal	490
Cast iron	450
Phosphor or leaded bronze	550
Lead	710
Preformed bearing pads	710

The City will measure Welded Stud Shear Connectors by the number of each installed and accepted.

513.30 Basis of Payment. If the fabricator's proposed methods of assembly with numerically controlled drilling or punching fail to produce specified results and the Engineer directs the Contractor to perform work, as according to 513.19 and 513.24, the City will not pay for this work.

For steel surfaces specified to be coated according to Item 514, the cost of applying a prime coat in the shop is incidental to the bid for structural steel.

The City will not pay for repairing or replacing members damaged by improper handling, storing, transportation, or erection.

The City will pay for the accepted quantities at the contract prices as follows:

Item	**Unit**	**Description**
513	Lump Sum	Structural Steel Members, Level UF
513	Lump Sum	Structural Steel Members, Level 1
513	Lump Sum	Structural Steel Members, Level 2
513	Lump Sum	Structural Steel Members, Level 3
513	Lump Sum	Structural Steel Members, Level 4
513	Lump Sum	Structural Steel Members, Level 5
513	Lump Sum	Structural Steel Members, Level 6
513	Pound	Structural Steel Members, Level UF
513	Pound	Structural Steel Members, Level 1
513	Pound	Structural Steel Members, Level 2
513	Pound	Structural Steel Members, Level 3

513	Pound	Structural Steel Members, Level 4
513	Pound	Structural Steel Members, Level 5
513	Pound	Structural Steel Members, Level 6
513	Each	Welded Stud Shear Connectors

ITEM 514 PAINTING OF STRUCTURAL STEEL

514.01 Description
514.02 Materials
514.03 Superintendent
514.04 Quality Control
514.05 Testing Equipment
514.06 Work Limitations
514.07 Protection of Persons and Property
514.08 Pollution Control
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514.21 Final Inspection
514.22 Repair Procedures
514.23 Method of Measurement
514.24 Basis of Payment

514.01 Description. This work consists of cleaning and painting all steel surfaces.

514.02 Materials. On existing steel, apply a three-coat paint system consisting of an organic zinc prime coat, an epoxy intermediate coat, and a urethane finish coat. The coating system shall conform to 708.02.

On new steel, apply a three-coat paint system consisting of an inorganic zinc prime coat, an epoxy intermediate coat, and a urethane finish coat. The prime coat shall conform to 708.01, and the intermediate and finish coats shall conform to 708.02. Supply the intermediate and finish coats from the same manufacturer. The Contractor is responsible for ensuring the compatibility of the intermediate and finish coats with the prime coat.

For caulking, use a single pack moisture cured polyurethane based material, which will not shrink or sag, capable of filling voids up to 1 inch wide. Only material that is listed on ODOT's Qualified Product List website may be used.

514.03 Superintendent. In addition to the requirements of 105.06, the Superintendent must successfully complete a Bridge Painting pre-qualification course and training offered by ODOT. The course must have been completed within the past four years and an individual course certificate must have been received by the Superintendent. Present certificate to the Engineer prior to commencing work. No work is permitted unless the Superintendent provides a valid course certificate.

514.04 Quality Control. Quality control consists of designating quality control specialists to control the quality of work in each phase established by Quality Control Points (QCPs). Control quality by inspection, tests, and cooperation with inspection and testing performed by the Engineer and inspector.

A. Quality Control Specialist. Identify the individuals dedicated to performing duties as the painting quality control specialists before starting work in the field. Provide a quality control specialist for each structure, but one quality control specialist must be provided for every three structures for which work is progressing concurrently on this contract.

Each quality control specialist must be, at a minimum, either a NACE (National Association of Corrosion Engineers) coating inspector Level 1-certified, or a SSPC (The Society for Protective Coatings, SSPC) protective coating specialist, or a SSPC protective coating inspector Level 1, or a SSPC bridge coating inspector Level 1, or formally trained or retrained by, at a minimum, a NACE coating inspector Level 1 certified, or a SSPC protective coating specialist, or a SSPC protective coating inspector Level 1, or a SSPC bridge coating inspector Level 1. The training shall be adequate to ensure that the quality control specialist is able to use all the testing equipment and understands the requirements of this specification. Provide a copy of the NACE or SSPC certification or a copy of the trainer's NACE or SSPC certification and a letter or certificate signed and dated by the trainer to the Engineer. Ensure that the NACE or SSPC certification is current or retrain the quality control specialist every five years in accordance with the above requirements.

The quality control specialist must successfully complete a Bridge Painting prequalification course offered by ODOT. The training course must have been completed within the past four years and an individual course certificate must have been received by the quality control specialist.

Select only a quality control specialist who is approved by ODOT. ODOT will publish a list of approved Quality Control Specialists. Present all required certificates, letters of certification, and valid identification to the Engineer prior to commencing work.

The quality control specialist will be immediately removed from their duties as the quality control specialist and disqualified from future duties as the quality control specialist if any quality control failure occurs. A quality control failure is defined as any of the following:

1. The dry film thickness has been approved by the quality control specialist and it is later found that over 20 percent of the spot measurements of any one member of a structure, such as a cross frame, web, flange, stiffener, or other parts of the structure are either under the minimum or over the maximum spot thickness.

2. The dry film thickness has been approved by the quality control specialist and it is later found that the thicknesses of any area of a structure as described in 514.20 are either under the minimum or over the maximum specification thickness.

3. Two separate occurrences when the surface preparation has been approved by the quality control specialist of any one member type, such as the cross frames, webs, flanges, stiffeners, or other parts of the structure and it is later found that the surfaces of those members were either not properly profiled or not properly cleaned as required by the Contract Documents. Occurrences are determined per structure.

4. Two separate occurrences of the quality control specialist performing production duties not allowed by the Contract Documents. Occurrences are determined per structure.

5. Two separate occurrences when the quality control specialist fails to perform any one of the duties assigned to the quality control specialist in the Contract Documents. Occurrences are determined per structure.

Suspend work if the quality control specialist is not available or has been removed. The Engineer or Inspector will immediately provide written notification to the Engineer of any quality control failure identified above. Resume work when a quality control specialist, qualified and approved as provided in 514.04, is available.

For work in the fabrication shop, each fabricator shall identify one or more full-time individuals who shall perform the duties of the painting quality control specialist.

The quality control specialist may not be used to perform production duties including supervision, blasting, painting, waste disposal, mixing, operating or repairing equipment, or other tasks not associated with duties of the quality control specialist while the Contractor is performing work toward the completion of a Quality Control Point (QCP).

Ensure that each quality control specialist is trained and equipped with Material Safety Data Sheets (MSDS), product data sheets, tools, and equipment necessary to provide quality control on all aspects of the work. Each quality control specialist shall have a thorough understanding of the plans for the work, including any pertinent addenda, change order, or other contract documents, and these Specifications. Duties each quality control specialist shall perform include:

1. Inspect equipment and abrasive at specified intervals.

2. Approve the work and provide documentation that the work has been approved immediately before each QCP.

3. Inspect the work with the Engineer or Inspector at each QCP.

4. Verify the Contractor or fabricator performed work according to the Contract Documents.

5. Cooperate with the inspection and testing performed by the Engineer and inspector.

6. Document test results and compare test results with the Engineer's and inspector's test results.

7. Notify Superintendent of nonconforming work.

8. Stop work when test equipment is not available and when necessary to ensure the work is performed according to the Contract.

The fabricator's quality control specialists shall provide the Engineer with a letter that includes specified information or check point data documenting acceptance of the work and consisting of the following:

1. Checks on the abrasive to ensure that it has not been contaminated with oil.

2. The profile of the blasted surface.

3. The air and steel temperature and dew point before blast cleaning and painting and at 4-hour intervals during the blasting and painting operation.

4. Readings of the actual dry film thickness.

5. The lot and stock number of the paint and the date of manufacture.

6. Documentation that the paint mixer is functioning properly, that each spray operator has demonstrated the ability to paint, and that all spray equipment is used according to the manufacturer's recommendation.

B. Quality Control Points (QCP). QCPs are points in time when one phase of the work is complete and approved by the quality control specialist and ready for inspection by the Engineer or the inspector before commencing the next phase of the work. At a QCP, the quality control specialist shall provide quality control tests bearing his signature to the Engineer or Inspector. The Contractor or fabricator shall provide the Engineer and inspectors access to inspect all affected surfaces. If inspection identifies a deficiency, correct the deficiency according to the Contract Documents before starting the next phase of work. Discovery of defective work or material after a Quality Control Point is past or failure of the

final product before final acceptance, shall not, in any way, prevent the City from rejecting the final product or obligate the City to final acceptance. **Final acceptance will be determined according to 514.21, Final Inspection.**

Quality Control Points	Purpose	New Steel	Existing Steel
1. Solvent Cleaning	Remove asphalt cement, oil, grease, etc.	Yes	Yes
2. Grinding Flange Edges	Remove sharp corners	Yes	Yes
3. Abrasive Blasting	Blast surfaces to receive paint	Yes	Yes
4. Containment/ Waste Disposal	Contain, collect, & dispose of abrasive blasting debris	No	Yes
5. Prime Coat Application	Check surface cleanliness, apply prime coat, check coating thickness	Yes	Yes
6. Remove Fins, Tears, & Slivers	Remove surface defects and slivers	Yes	Yes
7. Washing of Shop Primer	Remove all water soluble materials (salt, dirt, etc.)	Yes	No
8. Intermediate Coat Application	Check surface cleanliness, apply intermediate coat, check coating thickness	Yes	Yes
9. Caulking	Caulk areas not sealed by the intermediate coat	Yes	Yes
10. Finish Coat Application	Check surface cleanliness, apply intermediate coat, check coating thickness	Yes	Yes
11. Final Review	Acceptance and check total system thickness	Yes	Yes

Provide signed documentation of inspection, testing, conditions and material information to the Engineer on the following forms, or forms with the equivalent information.

QCS	Inspection Documentation Sign Off for QCP's	CI-BRG-11
QCP#1	Solvent Cleaning	CI-BRG-2
QCP#2	Grinding Flange Edges	CI-BRG-2
QCP#3	Abrasive Blasting	CI-BRG-3
QCP#3	QCS & Visual Standards Information for Abrasive Blasting Test Section	CI-BRG-1
QCP#4	Disposal of Hazardous/Non-Hazardous Waste	CI-BRG-4
QCP#5	Prime Coat Application	CI-BRG-5
QCP#5	Dry Film Thickness Readings for Prime Coats	CI-BRG-10
QCP#6	Grinding Fins, Tears and Slivers	CI-BRG-6
QCP#8	Dry Film Thickness Readings for Intermediate Coats	CI-BRG-10
QCP#9	Caulking	CI-BRG-6
QCP#8	Intermediate Coat Application	CI-BRG-7
QCP#10	Finish Coat Application	CI-BRG-7
QCP#10	Dry Film Thickness Readings for Finish Coats	CI-BRG-10
QCP#11	Bridge Painting Destructive Test Log	CI-BRG-8
QCP#11	Bridge Painting Final Review	CI-BRG-9

514.05 Testing Equipment. For the project duration, provide the Engineer or inspectors with the test equipment listed below for the type of work at each work site with ongoing work. With the exception of the recording thermometer, the fabricator shall provide its quality control specialists with the test equipment listed below. The Contractor and fabricator shall maintain all testing equipment in good working order, and provide documentation or certification of calibration from the manufacturer. If the Contractor or Fabricator and the Engineer's inspector are using different test equipment, the Contractor or Fabricator and the Engineer's inspector will perform side-by-side testing and compare results. If the difference between the City's and Contractor's or Fabricator's tests results, such as blast profile, dry film thickness, temperature, dew point and relative humidity, are greater than 1%, the Contractor or Fabricator and the Engineer will determine the reason for the differences and make necessary adjustments.

A. Provide a digital camera with the following features:

1. 5.0 Megapixel or greater resolution.
2. Minimum 3× Optical zoom lens capability with automatic focus.
3. Minimum 512MB Memory capability.

4. Built-in flash.

B. One Spring micrometer and extra-coarse replica tape or comparable electronic surface profile gauge for the measurement of abrasive blast profile depth within ±0.2 mils on the project at all times.

C. One SSPC-PA2 Type 2 (electronic) non-destructive coating thickness gage, with a set of calibration thickness foils, (shims), and two sets of National Institute of Standards & Technology calibration plates. The first set of calibration plates shall be 1.5 to 8 mils, Model No. 1362b, and the second set shall be 10 to 25 mils, Model No. 1363b. Other certified coating thickness standard plates for ferrous substrates must be approved for use by the Engineer.

D. One Sling Psychrometer including Psychrometric tables, (or comparable electronic or digital equipment for the measurement of dew point, accurate within 2 °F and within one percent relative humidity).

E. Two steel surface thermometers accurate within 2 °F.

F. Flashlight 2-D cell.

G. SSPC Visual Standard for Abrasive Blast Cleaned Steel (SSPC-VIS 1).

H. One recording thermometer capable of recording the date, time, and temperature over a period of at least 12 hours.

514.06 Work Limitations. Apply the prime coat to new structural steel inside permanent buildings at the fabricator's facility. If inside permanent buildings, the fabricator may perform year-round abrasive blasting and painting. Perform abrasive blasting and painting in the field from April 1 to October 31. The City will not issue a time extension due to adverse weather during the month of April. The plans or other Contract Documents may require additional work limitations for specific bridges or projects.

A. Temperature. Do not apply Inorganic Zinc Primer if the steel, air, and paint temperature is below 40 ºF. Do not apply Organic Zinc Primer, Epoxy Intermediate, or Urethane Finish Coats if the steel, air, and paint temperature is below 50 ºFºC). Follow the paint manufacturers printed instructions for the minimum times to handle, recoat and cure the individual coats for specified conditions and thicknesses.

Monitor and document that the temperatures listed below are maintained for minimum time frames listed below, after application of each coat, by using the recording thermometer. The Contractor may use a heated enclosure or building. Supply heat continuously and uniformly to maintain the required minimum temperature within the enclosure or building.

Minimum Times to maintain temp. per coating.	**50 °F**	**60 °F**	**70 °F**
Primer (Organic Zinc)	4 hrs	3 hrs	2 hrs
Intermediate (Epoxy)	6 hrs	5 hrs	4 hrs
Finish (Urethane)	8 hrs	6 hrs	4 hrs

If combustion type heating units are used, vent the units away from the enclosure or building and do not allow exhaust fumes to enter the enclosure or building. Do not use open combustion in the enclosure or building.

The fabricator may use radiant heat when painting new structural steel inside permanent shop buildings. Locate radiant heaters at least 10 feet above all surfaces to be painted. Vent exhaust fumes to prevent fumes from contacting surfaces to be painted.

B. Moisture. Do not apply paint:

1. If the steel surface temperature is less than 5 °F above the dew point.
2. If the steel surface is wet, damp, frosted, or ice-coated.
3. If the relative humidity is greater than 85 percent.
4. During periods of rain, fog, or mist unless the above moisture criteria is met.

If steel was abrasive blasted when the temperature of the steel was less than 5 °F above the dew point, reblast the steel when the steel temperature is at least 5 °F above the dew point.

514.07 Protection of Persons and Property. Collect, remove, and dispose of all rubbish, buckets, rags, or other discarded materials and leave the job site in a clean condition.

Except for deck bottoms and backwalls which have not been sealed or are not to have a sealer applied, protect all portions of the structure, that are not to be painted from damage or disfigurement by splashes, spatters, and smirches of paint.

If the Contractor causes any damage or injury to public or private property, the Contractor shall restore the property, to a condition similar or equal to the condition existing before the damage or injury.

514.08 Pollution Control. Comply with pollution control laws, rules, or regulations of Federal, State, or local agencies and requirements of this specification.

514.09 Safety Requirements and Precautions. Comply with the applicable safety requirements of the Ohio Industrial Commission and OSHA.

Provide Material Safety Data Sheets (MSDS) at the preconstruction meeting for all paints, thinners, and abrasives used on this project. Do not begin work until submitting the MSDS to the Engineer.

514.10 Inspection Access and Lighting. In addition to the requirements of 105.10, furnish, erect, and move scaffolding and other appropriate equipment to allow the inspector and the Engineer the opportunity to closely observe all affected surfaces during all phases of the work and for at

least 10 workdays after completely painting each structure to allow for the Final Inspection according to 514.21. Provide artificial lighting as necessary to supplement natural light with a minimum of 30 foot candles at the surface of the steel for inspection, cleaning, and painting. Prevent glare that interferes with traffic, workers and inspection. Submit to the Engineer for information, complete details of the inspection access that complies with the applicable safety requirements of The Ohio Industrial Commission and OSHA. The details shall be reviewed, signed, stamped and dated by an Ohio registered Professional Engineer certifying that they meet these requirements. Maintain the in-place inspection access equipment employed during original painting activities or provide alternate inspection equipment such as platform lifts, bucket trucks, snooper trucks, or equivalent as approved by the Engineer. If scaffolding, or any hanger attached to the scaffolding, is supported by horizontal wire ropes, or if scaffolding is directly under the surface to be painted, comply with the following requirements:

A. If scaffolding is suspended 43 inches or more below the surface to be painted, place two guardrails on all sides of the scaffolding. Place one guardrail at 42 inches above the scaffolding and the other guardrail at 20 inches above the scaffolding.

B. If scaffolding is suspended at least 21 inches but less than 43 inches below the surface to be painted, place one guardrail on all sides of the scaffolding at 20 inches above the scaffolding.

C. If 514.10.A and 514.10.B do not apply, place two guardrails on all sides of scaffolding. Place one guardrail at 42 inches above the scaffolding and the other guardrail at 20 inches above scaffolding.

D. Provide scaffolding at least 24 inches wide if guardrail is used and 28 inches wide if guardrail is not used and scaffolding is suspended less than 21 inches below the surface to be painted. If using two or more parallel scaffolding to achieve the proper width, rigidly attach the scaffolding together to prevent differential movement.

E. Construct guardrail as a substantial barrier, securely fastened in place and free from protruding objects such as nails, screws, and bolts. Provide a properly located opening in the guardrail to allow the Engineer and inspector access onto the scaffolding.

F. Construct guardrails and uprights of metal pipe, steel angles, or wood. If using pipe railing, provide pipe with a nominal diameter of at least 1 ½ inches. If using steel angle railing, provide 2 × 2 × 3/8-inch steel angles or other metal shapes of equal or greater strength. If using wood railing, provide 2 × 4-inch nominal stock. Space uprights no more than 8 feet on center. If using wood uprights, provide 2 × 4-inch nominal stock.

G. If the surface to be inspected is more than 15 feet above the ground or water, and the scaffolding is supported from the structure being painted, provide a safety harness (not a safety belt) and lifeline for the Engineer and inspector. The lifeline shall not allow a fall greater than 6 feet. Provide a method to attach the lifeline to the structure that is independent of the scaffolding, cables, and brackets supporting the scaffolding.

H. If scaffolding is more than 2.5 feet above the ground, provide an access ladder and equipment to attach the ladder onto the scaffolding capable of supporting 250 pounds with a safety factor of at least four uniformly space rungs, steps, cleats, and treads no more than 12 inches on center. Extend at least one side rail at least 36 inches above the landing near the top of the ladder.

I. If the distance from the ladder to the access point on the scaffolding exceeds 12 inches, provide an additional landing that is capable of supporting a minimum of 1000 pounds and at least 24 inches wide and 24 inches long. Size and shape the landing so that the distance from the landing to the point where the scaffolding is accessed does not exceed 12 inches. Firmly attach the landing to the ladder; however, do not use the ladder to support the landing.

J. In addition to the scaffolding requirements above, comply with all Federal, State, and local laws, ordinances, regulations, orders, and decrees.

K. Furnish all necessary traffic control to allow inspection during and after all phases of the project.

514.11 Job Site Visual Standards. Before starting abrasive blasting, establish job site visual standards by preparing a test section, subsequent test sections, and by using photographs of approved test sections. Use job site visual standards and SSPC-VIS 1 standard for blasting. The Contractor or fabricator shall prepare an approximately 20 to 30-square foot test section from a representative area on the first structure to be painted. After the Engineer or Inspector and the Contractor or fabricator agree the test area was blast cleaned to the requirements of the Contract Documents, photograph the test section and check the steel surface for the proper profile. After the Engineer or Inspector approves the test section and the job site visual standards are documented by photographs and replica tape, the Contractor or fabricator may start abrasive blasting. The quality control specialists and Engineer or Inspector will use the job site visual standards (photographs), the Plan, Specification and requirements to determine acceptance of blast cleaning procedures. In all cases of dispute, the SSPC-VIS 1 standard shall govern. If the Contractor, Engineer, Inspector, or fabricator believe the initial test section does not establish the proper visual standard for a different structure another test section on the different structure may be performed.

514.12 Quality Control Point Photographic Verification and Documentation. The Engineer or Inspector will take a sufficient number of photographs to document the condition of the work at Quality Control Points 3, 4 and 11.

514.13 Surface Preparation.

A. Solvent Cleaning (QCP #1). Solvent clean by methods described in SSPC-SP 1, areas containing oil, grease, asphalt cement, diesel fuel deposits, other petroleum products and contaminants.

B. Grinding Flange Edges (QCP #2). Before abrasive blasting, round all exposed flange edges of all beams and girders to a radius of 1/8 ±1/16 inch. This work has no weather and temperature restrictions. For shop painted steel, ground the sides of thermally cut material 1 ½ inch or thicker to remove the heat effected zone, as necessary, to achieve the specified surface cleaning.

C. Abrasive Blasting (QCP #3). Do not abrasive blast areas that contain asphalt cement, oil, grease, or diesel fuel deposits. Before abrasive blasting, completely remove all dirt, sand, bird nests, bird droppings, and other debris from the scuppers, bulb angles, and pier and abutment seats.

Abrasive blast all steel to be painted according to SSPC-SP 10 and as shown on the pictorial surface preparation standards for painting steel surfaces shown in SSPC-VIS 1. Maintain steel in a blast cleaned condition until it has received a prime coat of paint. The Contractor may commercial blast clean the back side of end cross frame assemblies that are 3 inches or closer to backwalls according to SSPC-SP 6.

Cover and protect galvanized and metalized steel (including corrugated steel bridge flooring), adjacent concrete already or specified to be coated or sealed, and other surfaces not intended to be painted, from damage caused by blasting and painting operations. Repair adjacent coatings damaged during the blasting operation. Backwalls and bottoms of decks not sealed nor specified to be sealed do not need to be covered and protected.

For field blasting use a recyclable steel grit, or a recyclable natural mineral, low dusting abrasive. Do not use silica sands, mineral slags, and other types of non-metallic abrasives that contain more than 0.5 percent free silica, by weight, have a chlorides salts content more than 25 ppm, and contain any organic material. For shop blasting, use an abrasive that produces an angular profile. All abrasives shall provide a profile from 1.5 to 3.5 mils as determined by replica tape according to ASTM D 4417, Method C. Adjust the abrasive size, blast hose nozzle pressure or other means in order to provide the 1.5 to 3.5 mil profile. Clean the abrasive of paint chips, rust, mill scale, and other foreign material after each use and before each reuse. Use equipment specifically designed for cleaning the abrasive.

Check abrasives used at the job site or fabrication shop for oil contamination at the beginning of each shift and at 4-hour intervals. Also check each load of abrasive delivered to the job site or fabrication shop for oil contamination before use. Check for oil by placing a small sample of abrasives and tap water into a jar. Reject the abrasive if an oil film is detected on the water surface.

To ensure that the compressed air is not contaminated, the quality control specialists shall blow air from the nozzle for 30 seconds onto a white cloth or blotter held in a rigid frame. If the cloth or blotter retains oil or other contaminants, suspend abrasive blasting until retests verify the problem was corrected. Perform this test at the start of each shift and at 4-hour intervals.

The Contractor may simultaneously abrasive blast and paint the same bridge provided the abrasive blasting debris and dust does not contact freshly painted surfaces and does not contaminate paint during the curing period. For shop blasting, the fabricator may simultaneously abrasive blast and paint if the two operations are separated by distance or containment that prevents paint contamination.

For surface preparation of new structural steel in the fabricator's shop, the quality control specialist shall take replica tape readings as follows:

1. For an automated blasting process, test the greater of 20 percent of the main members or one member per shift. These tests shall consist of taking five random readings per member.

2. For a manual blasting process, test each main member. The test of a main member consists of taking five readings at random locations.

3. For both an automated and manual blasting process, test 15 percent of all secondary members. The test of a secondary member consists of taking one random reading.

Remove abrasives and residue from all surfaces to be painted. Keep all structural steel that was blast cleaned in the field or the fabricator's shop dust free. Apply a prime coat to steel that was blast cleaned in the field within 12 hours of the beginning of the abrasive blasting operation. Apply a prime coat to structural steel that was blast cleaned in the fabricator's shop within 24 hours of the beginning of the abrasive blasting operation. If a prime coat is not applied within the times stated above, reblast the steel before applying the prime coat. Remove all dust or abrasives from adjacent work and from the finish coat.

Provide the Engineer and Inspector with field wash facilities and an adequate supply of running potable water, soap, and towels for washing face and hands during the surface preparation operation. Properly contain, test, and dispose of the wastewater. Locate a wash facility at each bridge site and in an area that will not be contaminated by the blasting debris.

D. Containment/Waste Disposal (QCP #4). Waste material generated by abrasive blasting operations in the field is a solid waste and may be a hazardous waste. Contain, collect, store, evaluate, and properly dispose of the waste material. Comply with all Federal, State, and local environmental protection laws, regulations, and ordinances including, but not limited to, air quality, waste containment, and waste removal. The Contractor is advised that various governmental bodies are involved with solid waste and hazardous waste disposal and the Contractor is responsible for complying with laws enforced by the various governmental bodies.

To prevent contamination of the pavement or soil, park all equipment on ground covers free of cuts, tears, and holes.

Clean equipment of spent abrasives or debris before bringing equipment to the project, moving equipment from one bridge site to another, and removing equipment from the project. Store debris cleaned from equipment with the debris from the structure that generated the debris.

Erect an enclosure to completely surround (around, under and over the top on truss type bridges) the blasting operations. The Contractor may use the ground as the bottom of the enclosure if the ground is completely covered with plastic or tarps.

Construct the enclosure of flexible materials such as tarpaulins (specifically designed for blasting containments), or construct the enclosure of rigid materials such as plywood. Maintain all materials free of tears, cuts, and holes. Overlap all seams a minimum of 6 inches and fasten the seams together at 12-inch centers or in a manner that ensures a seal that does not allow openings between the edges of the containment material. Extend the vertical sides of the enclosure completely up to the bottom of the deck on a steel beam bridge and use bulkheads between beams to enclose the blasting area.

Collect all debris from blasting operations, equipment, or filters, and all debris that fell to the ground. Store the debris in steel containers/drums with lids that are locked at the end of each workday. Store the debris in these locked drums while in the storage location and when hauled from the storage location to the disposal site. The storage location shall be at the bridge site unless, the Engineer and Contractor agree on an alternate storage location. Secure the storage location by surrounding the site with a 5 foot high dumpster or a 5 foot high chain link fence fabric supported by traffic

sign drive posts 10 feet apart. Drive the traffic signposts into the ground at least 2 feet deep. Secure the dumpster or fencing with padlocks at the end of each day. The location of centralized cleaning stations for recyclable steel shall also be agreed by the Engineer and the Contractor.

Test and evaluate the debris for disposal. Obtain the services of a testing laboratory to obtain directly from the project site and evaluate a composite representative sample of the abrasive blasting debris for each bridge site. The person taking the sample must be an employee of the testing laboratory.

Take composite sample in the presence of the Engineer or Inspector, comply with the requirements of U.S. EPA Publication SW 846 and take individual samples from all containers that are on the site at the time of the sampling. Blend individual samples of equal size together to comprise one composite sample. Take one individual sample from each drum and four randomly spaced individual samples from each container other than drums.

Take individual samples and place into clean glass or plastic containers.

Prepare a chain of custody record (Chain of Custody) for all composite samples. The Chain of Custody must include the name of the person taking the sample, the name of the testing laboratory for which the person works, the date and time the sample was taken, the bridge sampled, the Township and Municipality where the bridge is located, and the signatures and dates of all persons in possession of the sample in the Chain of Custody.

Sample the abrasive blasting debris within the first week of production blasting at each bridge. Cease all blasting and painting operations on the bridge from which waste was generated, if sampling is not performed within the first week of production blasting.

Test composite samples for lead, chromium, cadmium and arsenic according to the U.S. EPA Publication SW 846 Method 1311 (TCLP). Provide the Chain of Custody and test results to the Laboratory immediately after the test results are available. If the Laboratory determines the blasting debris is hazardous, as defined below, provide the Engineer with the names of the hauler and treatment facility. Perform all sampling and testing required by the hauler, treatment facility, or disposal facility.

The existing paint removed from bridges may contain lead, chromium, cadmium or arsenic. The Contractor is responsible for taking the proper safety precautions to ensure workers in this environment are properly protected.

1. Hazardous Waste. The blasting debris is hazardous if lead, chromium, cadmium or arsenic exceed any of the regulatory concentration limits shown below:

SW 846 Analyte	Regulatory Concentration Limit
Lead	5.0 mg/l
Chromium	5.0 mg/l
Arsenic	5.0 mg/l
Cadmium	1.0 mg/l

Label all the containers of hazardous blasting debris “HAZARDOUS”. Post hazardous waste warning signs at obvious locations on the fenced enclosure.

The Engineer will obtain a generator number assigned to the State. After the Engineer obtains the generator number, arrange for the hauling, treating, and disposing of the hazardous waste. Use a firm licensed by EPA to haul and dispose of the hazardous waste. This firm is also responsible for providing the completed Uniform Hazardous Waste Manifest (EPA Form 8700-22, or current version).

In every case, properly dispose of all hazardous waste within 60 days after it is generated. If hazardous waste is not properly disposed of within 60 days, the City will consider the Contactor in breach of its Contract and the City will take the following actions:

a. Immediately suspend all abrasive blasting and painting of structural steel on the Project until hazardous waste is properly disposed.

b. Cease processing all pay estimates.

c. Forward a breach of contract notification to the Contractor’s Surety.

The Contractor is responsible for fines or liens assessed by any governmental agency that has jurisdiction over the disposal of this hazardous waste material.

Decontaminate or dispose of all collection and containment equipment according to EPA guidelines.

The Contractor shall inform the City when all hazardous waste has been removed from the Project so the EPA Site ID Number (Hazardous Waste Generator Number) can be deactivated.

2. Non-Hazardous Solid Waste. For all waste that is determined to be a Non-Hazardous Solid Waste, the Contractor is required to:

a. Before disposing of any material, provide the Engineer with documentation that the disposal facility is licensed by the EPA to accept non-hazardous solid waste.

b. Haul and dispose of the waste to the documented, non-hazardous solid waste facility.

c. Obtain from the disposal facility and provide the Engineer with a receipt that documents disposal of waste material at the licensed disposal facility.

d. Properly dispose of all waste within 60 days after it is generated.

514.14 Washing Shop Primer (QCP #7). Wash shop primed structural steel after it is erected and the concrete deck is placed and within 30 days of applying the intermediate coat.

Wash the steel with potable water. Use equipment capable of delivering the water at a nozzle pressure of at least 1000 pounds per square inch and at a rate of not less than 4 gallons per minute. The Contractor shall provide the Engineer with equipment specifications that verify both the delivery pressure and rate. Provide gauges on the equipment to verify the pressure during operation. Hold the nozzle a maximum of 12 inches from the surface being washed. The surface is clean when clear rinse water runs off the structure. After rinsing the surface, inspect for remaining dirt and rewash dirty areas until clean.

514.15 Handling. Deliver all paint and thinner in original unopened containers with labels intact. The Engineer or Inspector will accept containers with minor damage provided the container is not punctured. Thinner containers shall be a maximum of 5 gallons. Before use, provide the Engineer with shipping invoices for all painting materials used on the Project.

Supply containers of paint and thinner with labels clearly marked by the manufacturer to show paint identification, component, color, lot number, stock number, date of manufacture, and information and warnings as may be required by Federal and State laws.

Store paint at the temperature recommended by the manufacturer and in a storage facility that prevents theft. Provide thermometers capable of monitoring the maximum high and low temperatures inside the storage facility.

Before opening paint or thinner containers, check the labels to ensure the proper container is opened and the paint has not been stored beyond its shelf life. Do not use paint that exceeded its shelf life. Do not open containers of paint and thinner until required for use and then open the oldest paint of each kind first. Solvent used for cleaning equipment is exempt from the above requirements.

Do not use paint that has livered, gelled, or otherwise deteriorated during storage. Properly dispose of unused paint and paint containers.

514.16 Mixing and Thinning. Thoroughly mix all ingredients immediately before use with a high shear mixer (such as a Jiffy Mixer). Do not mix paint using paddle mixers, paint shakers, or an air stream bubbling under the paint surface. After mixing, carefully examine the paint for uniformity and to ensure that no unmixed pigments remain on the bottom of the container. Before use, strain the paint through strainers that remove skins or undesirable matter but not pigment.

Except for primer, mix paint as necessary during application to maintain a uniform composition. Continuously mix primer using an automated agitation system. Do not use hand-held mixers for primer paints.

Do not add thinner to the paint without the Engineer's or Inspector's approval, and only add thinner if necessary for proper application as recommended by the manufacturer's printed instructions. In the Engineer's or Inspector's presence, slowly add the amount of thinner recommended and supplied by the manufacturer to the paint during the mixing process. Do not mix other additives into the paint.

Add catalysts, curing agents, or hardeners that are in separate packages to the base paint only after thoroughly mixing the base paint. With constant agitation, slowly pour the proper volume of catalyst into the required volume of base. Do not pour off liquid that has separated from the pigment before mixing. Use the mixture within the pot life specified by the manufacturer and dispose of unused portions at the end of each workday.

514.17 Coating Application.

A. General. Paint all structural steel, scuppers, expansion joints except top surface, steel railing, exposed steel piling, drain troughs, and other areas as shown on the plans. Paint galvanized or metalized surfaces if shown on the plans. Unless otherwise shown on the plans or specified below, apply paint to provide the specified coating thickness by brush and spray methods. Apply primer and intermediate paint per 708.01 and 708.02 to cover all visible steel surfaces. If gaps or crevices remain between adjacent coated steel surfaces after applying the intermediate coat, caulk according to 514.19. If brush and spray are not practical to paint places of difficult access, the Contractor may use daubers, small diameter rollers, or sheepskins.

Use daubers, small diameter rollers, or sheepskins to paint the following areas:

1. Where cross-frame angles are located within 2 inches of the bottom flange.
2. Where end cross frames are within 6 inches of the backwall.
3. Where there is less than 6 inches between the bottom of the bottom flange and the beam seat.

B. Application Approval. The Engineer or Inspector may inspect the initial application of the prime, intermediate, and final coats. If the Engineer or Inspector discovers defects, adjust the method of application to eliminate the defects then continue applying the coat.

C. Additional Information Pertaining to Shop Applied Paint. Apply a prime coat to all structural steel surfaces by brush or spray methods, including insides of holes, behind stiffener clips and contact surfaces of connection, and splice material that is to be fastened with bolts in the shop or field. Apply a mist coating from 0.5 to 1.5 mils on surfaces that are to be imbedded in concrete and on surfaces within 2 inches of field welds other than those attaching intermediate or end cross frames to beams or girders. Apply one coat of primer to pins, pin holes, and contact surfaces of bearing assemblies, except do not paint those containing self-lubricating bronze inserts. Once the prime coat is dry, apply erection marks, using a thinned paint of a type and color that is completely concealed by, and compatible, with the second coat.

Do not handle or remove coated structural steel from the shop until the applied paint has met the requirements as specified by the paint manufacturer's printed instructions.

Reduce the thickness of thick films of inorganic zinc primer by screening, sanding, or sweep blasting. If the primer paint cured longer than 24 hours, apply a re-coating of primer paint according to the paint manufacturer's printed instructions. Abrasive blast and re-apply the primer to

the affected area if “mud cracking” occurs. If “checking” occurs, abrasive blast and reapply the primer or remove the “checking” by screening and evaluate the area by adhesion testing.

If specified in the plans, furnish all necessary labor, materials and equipment to apply a three - coat paint system to Item 513 Structural Steel in the shop and touch up areas in the field.

Repair damage to the paint system caused during storage, transportation, erection, bolting, welding, forming, concrete placement, and form removal operation, according to 514.22. Repair damage to the galvanized coating on the nuts, bolts and washers, in the field due to the bolt tightening or welding operations. Exercise extreme care while handling the steel during erection, and during subsequent construction of the bridge. Insulate the steel from the binding chains by softeners and pad all hooks and slings that are used to hoist/erect the steel members.

Coating of Bolted Faying Surfaces

Treat the surfaces indicated below as described in this specification

A. Faying surfaces of all bolted connections.

B. All internal contact surfaces of filler and splice plates.

C. Other surfaces indicated in the plans.

Coat the faying surfaces of bolted splices with inorganic zinc primer in the shop. After erection is complete, field apply the final coatings of epoxy intermediate coat and urethane protective coats to overlap the shop coatings shown in Figure 1 with the field coats shown in Figure 2. For bolted crossframes, leave a minimum of one inch step back from faying surfaces, for epoxy intermediate and an additional one inch for urethane top coat.

Remove and reassemble all shop bolted connections and shop bolted cross frames prior to the blasting and coating of the girders or beams. Separately blast and prime the parts, then reassemble and fully tighten the bolts using the turn of the nut method. After bolting is complete, shop apply the epoxy intermediate and urethane protective coats.

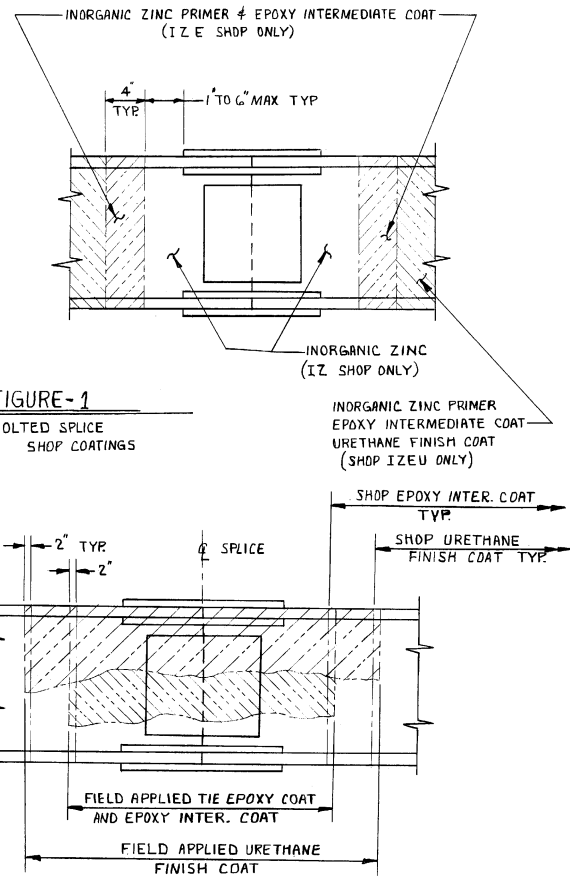

FIGURE-1
@ BOLTED SPLICE
SHOP COATINGS

FIGURE-2
@ BOLTED SPLICE
FIELD COATINGS

After installation, solvent clean all galvanized nuts, bolts, and washers. Remove any contaminants on the nuts, bolts and washers, prior to the application of paint. Repair any damaged galvanized coating and remove any corrosion prior to the application of organic zinc by brush. Then apply the epoxy coat and the urethane coats.

Erection marks added by the fabricator to highlight or enhance the required steel stamped erection marks must be made without damaging the paint system. Apply Erection marks only after the finish coat is cured and remove at the end of the project. Erection marks may be applied to the faying surfaces. These marks to the inorganic coating need not be removed but must be of a paint supplied by the IZEU system manufacture.

Remove any oil, grease, asphalt cement, concrete or other contaminants from the surface of the IZEU system painted structural steel.

D. Surface Cleanliness. All surfaces to be painted shall be free of dust, dirt, grease, oil, moisture, overspray, and other contaminants. If the surface is degraded or contaminated, restore the surface before applying paint. In order to prevent or minimize degradation or contamination of cleaned surfaces in the field, the prime coat of paint shall be applied within 12 hours of the beginning of the abrasive blasting operation as required in surface preparation above, for steel which is cleaned and painted in the shop, the prime coat of paint shall be applied within 24 hours of the beginning of the blasting operation.

Schedule cleaning and painting when dust or other contaminants will not fall on wet, newly painted surfaces. Protect surfaces that do not receive paint or have already been painted from the effects of cleaning and painting operations. Before applying the next coat, remove overspray and bird droppings with a stiff bristle brush, wire screen, or a water wash with sufficient pressure to remove overspray and bird droppings without damaging the paint. Before applying the next coat, remove all abrasives and residue from painted surfaces with a vacuum system equipped with a brush type cleaning tool.

Remove all visible abrasives on the finish coat that came from adjacent work.

E. Brush Application. Apply the paint to produce a smooth coat. To ensure coverage, apply wet stripe coats using brushes, daubers, small diameter rollers or sheepskins to all edges, outside corners, crevices, welds, rivets, bolts, nuts and washers in addition to the spray application of each individual coating. Apply stripe coat of organic zinc primer either before or after spray application of primer. Apply stripe coats of intermediate and finish coats before spray application of the respective coats. Apply additional paint as necessary to produce the required coating thickness.

F. Spray Application (General). Apply paint using spray application as follows:

Keep spray equipment clean so that dirt, dried paint, solvents, and other foreign materials are not deposited in the paint film. Remove solvent left in the equipment before using the equipment.

Apply paint in a uniform layer with overlapping at the edges of the spray pattern. Paint the border of the spray pattern first, followed by painting the interior of the spray pattern. Complete painting a spray pattern before moving to the next spray pattern area. Within a spray pattern area, hold the gun perpendicular to the surface and at a distance that will ensure a wet layer of paint is deposited on the surface. Release the trigger of the gun at the end of each stroke. Each spray operator shall demonstrate to the Engineer or inspector the ability to apply the paint as specified before the operator sprays paint.

If mud cracking occurs, the affected area shall be cleaned to bare metal in accordance with surface preparation above and repainted. Use spray equipment recommended by the paint manufacturer and suitable for use with the specified paint. Provide adequately sized traps or separators to remove oil and condensed water from the air. Periodically drain the traps during operations. To ensure that the traps or separators are working properly, test by blowing air from the spray gun for 30 seconds onto a white cloth or blotter held in a rigid frame. The Engineer or Inspector will verify the test results by inspecting the white cloth or blotter. If the cloth or blotter retains oil, water, or other contaminants, suspend painting until retests verify the problem was corrected. Perform this test at the start of each shift and at 4-hour intervals. This is not required for an airless sprayer.

Do not use spray application unless the operation is totally enclosed as required for abrasive blasting, to prevent overspray damage to the ground, public and private property, vegetation, streams, lakes, and other surfaces not to be painted.

G. Prime, Intermediate, and Finish Coat Application (QCP #5, #8, and #10). Apply paint as a continuous film of uniform thickness, free of all defects such as holidays, pin holes, mud cracking, checking, drips, runs, and sags. The Contractor is responsible for applying the manufacturer's paint as necessary to satisfy the above requirement. Repaint all thin spots or areas missed before the next coat of paint is applied.

Ensure that the paint manufacturer's printed instructions for the minimum times to handle, recoat and cure the individual coats for specified conditions and thicknesses are followed for each coat of paint before applying the next coat. Comply with the manufacturer's written instructions for the time interval between coats and apply the next coat when an additional coat will not cause detrimental film irregularities, such as lifting, wrinkling, or loss of adhesion of the undercoat. Do not exceed the following time intervals. If the prime coat is organic zinc, the maximum time between the prime and intermediate coats is 30 days. There is no maximum time between the prime and intermediate coats for an inorganic zinc primer. The maximum time interval between intermediate and finish coats is 13 days. These maximum recoat times include adverse weather days and the Engineer will not extend the times. If the next coating is not applied within the times stated above, remove the coatings and re-blast the steel according to SSPC-SP 10.

If requested by the engineer, perform one or both of the following test to determine the hardness and or the adhesion of an individual coating or the coating system:

1. Determine the hardness of an individual coat or the coating system by performing a Pencil Hardness Test according to ASTM D 3363. Meet or exceed scale of hardness HB for the coating.

2. Perform Adhesion Testing according to ASTM D 4541, Type 4. Meet or exceed 400 psi adhesion between coats or between the paint system and the substrate, or 400 psi cohesion within paint coats.

Stencil the Completion Date (month and year) of the finish coat and the letters of the applied paint system on the steel in 4 inch letters with black urethane paint. The appropriate letters for the paint systems are as follows:

System Comprised of:	Letters
Inorganic zinc prime coat, epoxy intermediate coat, and urethane finish coat	IZEU
Organic zinc prime coat, epoxy intermediate coat, and urethane finish coat	OZEU

Apply the date and paint system at four locations near the end of each outside beam on the outside web visible from the road or as directed by the Engineer.

514.18 Removing Fins, Tears, or Slivers (QCP #6). Use a grinder to remove all fins, tears, slivers, or any other burred or sharp edges that become evident after applying the prime coat. Retexture ground surfaces to produce a profile from 1.5 to 3.5 mils and reprime ground surfaces before applying the intermediate coat. The Contractor may begin removing fins, tears, and slivers after blasting and before priming. Temperature and weather restrictions do not apply to removing fins, tears, and slivers, but do to applying the prime coat.

514.19 Caulking (QCP #9). After the intermediate coat cures and before applying the finish coat, caulk gaps or crevices up to 1/2 inch wide. Follow the manufacturer's recommendations for curing before applying the finish coat.

514.20 Dry Film Thickness (QCP #5, #8, and #10). Determine prime coat thickness; prime and intermediate coat thickness; and prime, intermediate, and finish coat thickness using a Type 2 magnetic gage as follows:

Measure paint thickness at separate, evenly spaced, spot measurement locations over each 100-square feet of area of structural steel. Locate five spot measurements on each of the following locations: top flanges; bottom flanges; webs; cross bracing; stiffeners; etc. At each spot location, take three gage readings of either the substrate or the paint. Move the probe 1 to 3 inches for each new gage reading. Discard an unusually high or low gage reading that is not consistently repeated. The spot thickness measurement is the average of the three gage readings.

The average of five spot measurements for each location in the 100-square foot area shall not be less than the specified thickness. No single spot measurement area shall be less than 80 percent of the specified minimum thickness nor greater than 150 percent of the maximum specified thickness when organic zinc is applied and 120 percent of the maximum specified thickness when inorganic zinc is applied. Any one of three readings which are averaged to produce each spot measurement, may under run or overrun by a greater amount. Take five spot measurements per location for each 100-square foot area as follows:

A. For all shop painted steel, regardless of size, randomly select and then measure one 100-square foot area within each 300 square foot unit of surface area that is painted.

B. For structures not exceeding 300 square feet in area, measure each 100-square foot area.

C. For structures not exceeding 1000 square feet in area, randomly select and then measure three 100-square foot areas.

D. For structures exceeding 1000 square feet in area, measure the first 1000 square feet as stated in section C and for each additional 1000 square feet, or increment thereof, randomly select and then measure one 100-square foot area.

E. If the dry film thickness for any 100-square foot area (sections C and D) is not in compliance with the requirements of this subsection, then measure each 100-square foot area.

F. Measure other areas or revise the number of spot measurements as shown on the plans.

Each coat of paint shall have the following thickness measured above the peaks:

	Min. Spec. Thickness	Max. Spec. Thickness	Min. Spot Thickness	Max. Spot Thickness (Inorganic Zn)	Max. Spot Thickness (Organic Zn)
Prime	3.0 mils	5.0 mils	2.4 mils	6.0 mils	7.5 mils
Intermediate	5.0 mils	7.0 mils	4.0 mils	10.5 mils	10.5 mils
Subtotal	8.0 mils	12.0 mils	6.4 mils	16.5 mils	18.0 mils
Finish	2.0 mils	4.0 mils	1.6 mils	6.0 mils	6.0 mils
Total	10.0 mils	16.0 mils	8.0 mils	22.5 mils	24.0 mils

Remove paint with a film thickness greater than the maximum specified thickness unless:

The paint does not exhibit defects such as runs, sags, bubbles, or mud cracking, etc.
The manufacturer provides a written statement to the Engineer that the excessive thickness is not detrimental.

For any spot or average of five spots at any location of a 100-square foot area that exceeds the maximum spot thickness, either remove and replace the coating according to 514.22 or prove to the Engineer that the excess thickness will not be detrimental to the coating system. In order to prove to the Engineer that the excess thickness will not be detrimental to the coating system, the Contractor must provide the Engineer with the following information.

Certified test data proving that the excessive thickness will adequately bond to the steel when subjected to thermal expansion and contraction. The thermal expansion and contraction test shall take place over five cycles of a temperature range from -20° to 120 °F. After the thermal contraction and expansion cycles have taken place, the tested system shall be subjected to pull off tests and the results compared to the results of pull off tests that have been performed on a paint system with the proper thicknesses.

Perform the adhesion tests according to ASTM D 4541 Type IV. Document the preparation methods for the panels, including profile and level of cleanliness. Document the application methods, conditions and if any thinner, (percentage), was used. Test the panels according to the following:

1. Lightly sand the coating surface and aluminum dolly, and apply a quick set adhesive. Document the type of adhesive.
2. Allow adhesive to cure overnight.
3. Scribe the coating and adhesive around the dolly before testing.
4. Make a minimum of 4 trials to failure, and report the 4 trials. Reject trial if fracture occurs at the primer-substrate interface or pressure at failure is less than 400 pounds per square inch.
    a. Describe the test specimen as substrate A, upon which successive coating layers B, C, D, etc. have been applied including the adhesive Y which secures the dolly Z to the topcoat.
    b. Designate cohesive failures by the layers within which they occur as B, C, etc., and the percent of each.
    c. Designate adhesive failures by the interfaces at which they occur as A/B, B/C, C/D, etc, and the percent of each.

In addition to the certified test results, the Contractor shall provide the Engineer a written statement from the paint manufacturer stating that the excessive thickness is not detrimental.

If the Engineer does not approve the excessive coating thicknesses or the Contractor elects not to provide the required written statement from the paint manufacturer and the certified test results when required, the Contractor shall remove and replace the coating. The removal and replacement of the coating shall be done as specified in 514.19.

514.21 Final Inspection.

A. The Engineer will select locations for coating removal for inspection of surface preparation and dry film thickness. For all structures in which the supporting members are rolled beams or girders, remove a minimum of one location per 150 linear feet of beam line for webs and flanges and 5 percent of all cross frame assemblies and other secondary structural members shall be selected for destructive testing. For all other bridge types with structural steel, remove one location for every 1,200 square feet of steel surface for destructive testing. Do not perform destructive testing on areas that have been painted with an inorganic zinc prime coat.

B. At the selected areas, the Engineer will perform total dry film thickness testing using a type 2 magnetic gage. If the dry film thickness for that spot does not meet the requirements of 514.18, additional measurements will be taken to determine the extent of the deficient coatings.

C. At the selected areas, where an organic zinc prime coat has been applied, remove at least 9 square inches of the new coatings by methods that will not damage the surface of the steel. Approved removal methods are scraping, sanding, or the use of solvents. Do not use power tools. Perform removal while in the presence of the Engineer. The Engineer will document and photograph the selected areas after removal of the new coatings. If work is found not to be in conformance with the specifications and pertinent contract documents, additional locations may be selected for testing.

D. Make repairs of areas where the coatings were removed and other areas that were determined to be deficient. Make repairs according to 514.22. If the final destructive testing according to 514.21.C, reveals greater than 15 percent of the areas inspected are not in complete conformance with the specifications and pertinent contract documents, the City will require that surface preparation and painting of the structural steel be completely redone to meet the requirements of the Contract Documents at no additional cost to the City.

E. Final Acceptance shall be based upon the results of the surface preparation observations and dry film thickness measurements obtained from the final inspection. Final Acceptance will also take into consideration acceptable progressive project documentation and progressive field measurements in determining the final acceptability of the Bridge Paint System.

Inspection access to the test locations to perform the required final inspection measurements shall conform to the requirements of 514.10.

514.22 Repair Procedures. Remove paint and correct defects or damaged areas, including areas damaged by welding, and in areas that do not comply with the requirements of this specification. Correct defects and damaged areas using the same paint as originally applied except the Engineer may approve using organic zinc to repair inorganic zinc in the field. Retexture the steel to a near white condition and a profile between 1.5 to 3.5 mils. Measure the profile immediately before applying the prime coat to ensure the profile is not destroyed during the feathering procedure. See 513.14.C.

Feather the existing paint to expose a minimum of 1/2 inch of each coat.

During the reapplication of the paint, apply paint as follows:

A. Apply the prime coat only to the surface of the bare steel and the existing prime coat exposed by feathering. Do not apply the prime coat to the adjacent intermediate coat.

B. Apply the intermediate coat only to the new prime coat and the existing intermediate coat exposed by feathering. Do not apply the intermediate coat to the adjacent finish coat.

C. Apply the finish coat only to the new intermediate coat and the existing finish coat that was feathered or lightly sanded. Do not apply the finish coat beyond areas that were feathered or lightly sanded.

At the perimeter of the repair area, apply the prime and intermediate coats using a brush. Apply the finish coat using either brush or spray.

The Contractor may need to apply several applications to obtain the proper thickness for each coat.

During the application of the prime coat, the paint shall be continuously mixed.

Perform all surface preparation and painting according to this specification. Instead of abrasive blasting, the Engineer may allow alternate methods of preparing the surface.

Blend repair areas with the adjacent coating and provide a finished surface in the patched areas that is smooth and has an even profile with the adjacent surface.

Submit, in writing, the method of correcting areas with runs to the Engineer for approval.

514.23 Method of Measurement. The City will measure Surface Preparation of Existing Structural Steel and Field Painting of Existing Structural Steel Prime Coat by the number of square feet of structural steel painted or on a lump sum basis. The City will measure Field Painting Structural Steel, Intermediate Coat and Field. Painting Structural Steel, Finish Coat by the number of square feet or pounds of structural steel painted, or on a lump sum basis.

The City will determine the number of pounds of new structural steel painted by the accepted pay weight of the new structural steel.

For steel beam and steel girder bridges, the City will determine the surface area by taking a nominal measurement of the beams (i.e., two times the beam depth plus three times the flange width). In addition to this nominal measurement, the City will add a percentage to account for incidentals such as cross frames, bearing assemblies, stiffeners, expansion joints, scuppers, etc. It is not necessary for the Engineer or Inspector to field measure every detail of the bridge to verify quantities. If there is a quantity dispute, exact field measurements of all painted surfaces and calculations will govern over the above percentage to account for incidentals.

For extremely complex bridges, such as trusses, the City will pay for painting on a lump sum basis.

The City will measure grinding fins, tears, slivers on existing structural steel by lump sum. The City will not measure grinding fins, tears, and slivers on new steel but will consider it incidental to unit price for the new steel.

514.24 Basis of Payment. The City will pay for accepted quantities at the Contract prices as follows:

The City may consider paint as eligible for payment for material on-hand as specified in 109.10, however, only paint that the Contractor can prove to the Engineer will be used during the construction season is eligible for payment. The Contractor shall provide the Engineer calculations indicating the total square feet of steel to be painted during the construction season. The Contractor shall also provide calculations showing the total number of gallons required.

If the Contractor causes damage or injury to public or private property, the City will not pay for restoring the property to its original condition.

The City will not pay for repairing adjacent coatings damaged during the blasting operation.

The City will not pay for removing and replacing an area of coating because a spot or maximum average thickness exceeds the maximum spot thickness.

The City will not pay for additional testing required by any hauler, treatment facility, disposal facility or landfill.

The City will pay for caulking under Field Painting Structural Steel, Intermediate Coat.

The City will pay for final inspection access, test area preparation and test area repair at each selected area under Final Inspection Repair. The City will not pay for accessing, inspecting, and repairing areas that are not found to be in conformance with the specifications and pertinent contract documents.

All other requirements of this specification are considered incidental to the work.

Item	Unit	Description
514	Square Foot, or Lump Sum	Surface Preparation of Existing Structural Steel
514	Square Foot, or Lump Sum	Field Painting of Existing Structural Steel, Prime Coat
514	Square Foot, Lump Sum, Pound	Field Painting Structural Steel, Intermediate Coat
514	Square Foot Lump Sum, Pound	Field Painting Structural Steel, Finish Coat
514	Lump Sum	Grinding Fins, Tears, Slivers on Existing Structural Steel
514	Each	Final Inspection Repair
514	Square Foot Lump Sum, Pound	Shop Painting and Field Touch-Up of Structural Steel

ITEM 515 PRESTRESSED CONCRETE BRIDGE MEMBERS

515.01 Description
515.02 Fabricator Approval Procedure
515.03 Levels of Fabricator Qualification
515.04 General
515.05 Fabricator Documentation Responsibility

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515.16 Release of Prestressing Strands
515.17 Fabrication Tolerances
515.18 Prestressed Member Acceptance and Repair
515.19 Handling, Storage, Transportation, and Erection
515.20 Safety Requirements
515.21 Method of Measurement
515.22 Basis of Payment

515.01 Description. This work consists of preparing shop drawings, furnishing and manufacturing prestressed concrete bridge members, testing, fabricator performed quality control, documentation, shop coating, and handling, transporting, storing, and erecting prestressed concrete bridge members. Prepare shop drawings and erect prestressed concrete bridge members, according to Item 501 and the additional requirements specified below. Shop coating shall conform to Item 512.

515.02 Fabricator Approval Procedure. Select fabricators that are pre-qualified and evaluated by the Laboratory according to ODOT Supplement 1079 and listed by ODOT before the Contract letting Date.

515.03 Levels of Fabricator Qualification. There are three levels of fabricator qualification. The Laboratory will classify each fabricator at the highest level of fabrication it is qualified to perform.

Level	Description of Capabilities
1	Straight strand prestressed box beam members
2	Straight strand prestressed I-beam members
3	Draped strand prestressed I-beam members

515.04 General. Produce all members according to Item 511, except as otherwise specified herein.

515.05 Fabricator Documentation Responsibility. The fabricator shall keep and maintain records for each project bid line number concerning:

A. Fabricator plant approval.

B. Shop drawing approval.

C. Material test reports.

D. Welding qualifications.

E. Quality Control Plan (QCP) according to ODOT Supplement 1079.

The fabricator shall provide access to the above records for audit, inspection, and copying. Provide a copy of the complete records at the completion and final shipment of the work. The Fabricator shall retain all documentation for at least 5 years from the date of final shipment from the fabrication shop.

The fabricator shall document all Quality Control (QC) activities to verify the fabrication conforms to the specification requirements. QC activities include material quality checks, dimensional checks, weld inspections, strand tensioning procedures, release procedures, post-pour inspections, concrete strengths at release of strand and final strength of concrete before shipment, cleaning operations, coating applications, final QC inspections, repairs and all other QC procedures required to provide a prestress concrete member conforming to the specifications.

ODOT Supplement 1079 defines the quality control plan evaluation process and quality control plan enhancement process.

The City will perform a quality assurance (QA) evaluation of the fabricator's quality control performance using forms in ODOT Supplement 1079 and will include both validation of the fabricator's actual records of inspection and City inspection.

515.06 Shop Drawings. Provide shop drawings conforming to 501.04 and the following requirements.

Include all details, dimensions, dimensional tolerances, and size of materials, lifting devices, inserts, reinforcing steel supports, fabricator incorporated reinforcing, piece mark diagrams for field connection and erection of any steel and all prestress members, and all other information necessary for the complete fabrication and erection of the prestressed members. Show all items that will be incorporated into each prestressed member.

Provide the detensioning procedure and pattern conforming to 515.16.

515.07 PreFabrication Meeting. At least 3 days after the City receives shop drawings, conduct a prefabrication meeting at the fabricator's facilities, or another location agreed to by all parties.

As part of the prefabrication meeting request, provide a initial fabrication schedule for the prestressed beam project including:

A. Start date for fabrication of the project

B. Expected phasing of fabrication, if any

C. Number of workdays for the project and length of work day

D. Quality control final inspection date

The fabricator's production manager, quality control specialists (QCS) for the project, the City's inspector, and the Contractor, or its designated representative, shall attend the meeting. The meeting is to review fabrication issues, including information on shop drawings, previous QC/QA inspection issues, QC and Quality Assurance inspection hold points, unique and special fabrication items, and special processes. The QCS will conduct the meeting and record and distribute meeting minutes that document all issues discusses. Begin fabrication when all meeting issues have been resolved.

The Engineer may waive the prefabrication meeting if accepted by the Fabricator and the Contractor. If Contractor submitted shop drawings do not comply with the requirements of 515.06, no prefabrication meeting can be scheduled or waived.

515.08 Materials. Furnish materials conforming to:

Reinforcing steel	509
Concrete	515.15
Portland cement	701.01 thru 701.09
Aggregate *	703.02
Air-entraining admixture	705.10
Chemical admixtures for concrete	705.12
Prestressing steel	711.27
Transverse tie rods	711.01
Welded wire reinforcement	709.12

* For fine aggregate, use natural sand for members without a separate wearing course. Modify coarse aggregate as follows:

Do not allow more than 0.4 percent deleterious materials.

For gradation, use No. 6, 67, 68, 7, 78, or 8 size coarse aggregate.

515.09 Materials Approval. The fabricator shall control, test, and validate material requirements for all materials either incorporated into the prestressed fabricated item or supplied under Item 515 as component parts to the fabricated items. The fabricator shall provide ODOT Supplement 1079 documentation to the inspector at the time of final inspection.

The City will not sample materials at the fabricator's shop for City approval. The City will randomly sample materials to verify the fabricator's performance.

515.10 Casting Beds. Use steel or concrete casting beds set above grade to ensure the beds remain above the accumulation of water resulting from production and curing operations. Design beds and abutments capable of safely resisting all forces applied to them without appreciable movement or deflection. These forces include compression and eccentric forces due to end-jacking operations, forces at hold down points when draped strands are used, and downward forces due to the dead weight of the members.

515.11 Weather Conditions during Production. Make temperature change adjustments to initial strand tensioning according to PCI Quality Control Manual 116.

A. Cold Weather. Conform to the requirements of this subsection if the ambient air temperature is below 50 °F. Heat mixing water, aggregates, or both as necessary to produce a concrete temperatures from 50 to 70 °F when placed. Do not allow water heated above 150 °F to directly contact the cement. Do not place concrete against forms, reinforcing steel, prestressing strand, or other hardware materials with a temperatures below 32 °F.

Do not place concrete when the ambient temperature with sustained wind chill factor at the point of concrete placement is below 0 °F.

B. Hot Weather. If the ambient temperature is above 90 °F cool the mixing water, aggregates, or both, as necessary to produce a concrete temperature from 70 to 90 °F. Do not place concrete against forms, mild reinforcing steel, prestressing strand, or other hardware materials with a temperature greater than 120 °F.

Water fog spray forms, mild reinforcing steel and strand just prior to placing the concrete. Cover beams immediately after casting to prevent surface drying.

Do not place concrete when the ambient temperature at the point of concrete placement is above 100 °F.

C. Inclement Weather. If a rainfall event begins after placement of concrete in the forms has begun, provide cover and complete only the beam that had concrete in it when the rain began. Provide immediate cover over previously poured concrete, not yet cured. Resumption of concrete placement is permitted after the rainfall stops.

515.12 Equipment. Provide hydraulic jacks of sufficient capacity and stroke to tension strands. Use either single or multiple strand tensioning. Provide tensioning jacks equipped with automatic cutoff valves and equipped with 6 inch minimum diameter gages that provide readings at 500-pound increments. Calibrate gages for the jacks with which they are to be used. Have a graph or table showing the calibration available for the inspector. Calibrate jacks according to a method acceptable to the Laboratory at least every 12 months or as required by the Engineer. Maintain calibration documentation as part of the project's QC inspection records.

Design the jacking system to ensure uniform stress in all strands. If simultaneously tensioning multiple strands, use approved types of dynamometers to equalize the initial stress on all strands before applying the full tensioning load with the master jack. Provide dynamometers with sufficient capacity to ensure that the desired readings are in the middle to upper range.

515.13 Inspection Facilities. The fabricator shall provide the inspector office accommodations conforming to the following requirements:

A. Minimum floor area of 120 square feet.

B. Minimum ceiling height of 7 feet.

C. Adequate working and storage facilities, work space, lighting, electrical outlets, lockable files or cabinets and ventilation.

D. Heat capable of maintaining a temperature of not less than 68 °F.

E. Telephone with direct access to an outside trunk line for the inspector's exclusive use.

F. A set of keys for the lockable files or cabinets in the office.

515.14 Construction Methods. Use metal forms capable of producing members within the tolerances shown on the plans. Forms made of material other than metal may be used for bulkheads and voids. Ensure that the surfaces of the forms in contact with the concrete are smooth and the joints between panels are tight. The soffit form shall have a plane surface at right angles to the vertical axis of the members and have the two bottom edges beveled 3/4 inch with a triangular strip built into the forms. Increase the length of the forms for elastic shortening and normal concrete shrinkage, and design the forms to accommodate this movement.

Provide water-resistant formwork for box beam voids constructed of a material that resists breakage and deformation during placement of concrete. Provide form material that does not excessively increase the dead load of the beams.

Prevent the release agent from contacting the prestressing strands or reinforcing steel.

Install and assemble reinforcing steel according to the approved shop drawings. If authorized, weld reinforcing cages using welders qualified to AWS D1.4. Do not weld epoxy coated or galvanized reinforcing steel unless approved by the Engineer. Repair all coating areas damaged by welding according to the coating manufacturer's instructions. Reject reinforcing steel with a loss of cross-section of reinforcing caused by welding.

Provide a protective covering for the prestressed steel from the elements until the strand is pulled into the bed. Accurately place strands in the positions shown on the shop drawings. Do not use strands with kinks, bends, nicks, broken wires, scale, loose rust, or other defects. The fabricator may use slightly rusted reinforcing steel provided the rust is not sufficient to cause visible pits. Before placing the concrete, carefully clean the strands of all dirt, grease, oil, or other foreign matters. Do not splice strands within a member.

Tension strands uniformly to the stress indicated on the shop drawings. If multiple stands are stressed simultaneously, use dynamometers to equalize the initial stress on all strands before applying full tension load with master jack. Measure the required stress in the strands using the calibrated jacking equipment gages, and check the measured stress by the elongation of the strands. If the stress from the gages and the measured elongation are not within a 5 percent tolerance of the design, stop stressing the strands and determine the reason for the differences. The quality control specialist shall keep a record of the jacking forces and elongations of all strands. Secure the strands by suitable anchorage devices capable of developing at least 85 percent of the ultimate strength of the strands. The anchorage shall not allow the strand to slip after the tensioning operation.

If using draped strands, the loss of stress due to friction shall not exceed 5 percent. Tension the strands at both ends. The quality control specialist shall measure the loss due to friction by a procedure approved by the Engineer. Place hold-down points within 3 inches of the locations shown on shop drawings and within 12 inches of the locations shown on the plans.

Unless otherwise shown in the plans, do not install inserts or holes in the beam web within a distance of 1.5 times the beam height from the end of the beam.

515.15 Concrete. The fabricator shall provide concrete mix designs to Office of Material Management. The submittal will include:

A. Test data showing the mix achieves the required 28-day strength when cured by methods used for member fabrication. The strength of the concrete for the mix design approval and during production is determined using sets of two, 6 × 12-inch cylinders or three, 4 × 8-inch cylinders.

B. w/c ratio (maximum =0.40)

C. A design and maximum slump

D. Test data showing the mix design achieves 2000 coulombs or less at 90 days when tested according to AASHTO T277. Use samples for the test that were mixed without corrosion inhibitors and that were cured with the same methods that will be used to produce the prestressed concrete bridge members. Do not apply additional cure to samples that have reached the required design strength.

Changes in proportioning, cement, pozzolans or aggregate will require retesting and resubmittal. The Engineer may waive the retests. Provide the waiver request in writing and include all information for the new mix design and a comparison to the previously tested and approved mix design(s).

Deliver concrete according to Item 499, except that 499.03 and 499.04 do not apply. The plastic air content of the concrete before placement shall be 6 ± 2 percent. If the City questions the concrete's placed air content, obtain cores from the prestressed member and have hardened air testing performed by an independent testing lab acceptable to the City. Beams with hardened air contents below 4 percent will be rejected. Add an approved corrosion inhibiting admixture at the approved dosage and document the dosage that has been incorporated into each batch of concrete.

Maintain the mix design slump during production. Segregation of the mix is not acceptable. Do not exceed the maximum water-cement ratio during concrete production. When using admixtures to increase the slump, use Type F or G as described in 705.12. Do not use calcium chloride or admixtures containing calcium chloride.

For beams containing up to 20 yards of concrete each, make at least two cylinders from both the first and last loads placed on each casting bed, each day. If producing more than 200 feet of beam on the same bed, make at least two additional cylinders for each additional interval of 100 feet or part thereof. In general, produce the additional cylinders from a load placed in the middle of the additional member length. The QCS shall determine the exact location for these samples.

For beams containing between 20 and 35 yards of concrete, make at least one set of two cylinders per beam. For beams containing more than 35 yards of concrete, make at least two sets of two cylinders per beam.

Determine strength, for both strand release and final shipping, by testing a group of cylinders, which consists of one cylinder from every sample location. Each group of cylinders shall have an average strength of what is specified in the shop drawings, and no individual cylinder shall have less than 95 percent of the specified strength.

The inspector may require additional cylinders from locations were the concrete does not conform to mix design or placement requirements. Include these additional cylinders in the group of cylinders for determining release and final strength.

The fabricator may place concrete in the bottom flange of a box beam before placing the interior forms and reinforcement for the upper portion of the member, provided continuous concrete placement is not interrupted for more than 45 minutes.

Screed the top surfaces of non-composite members and finish the surface with a burlap drag or other means to provide a uniform surface with a gritty texture suitable for waterproofing.

Screed the top surface of composite members and finish the surface with a wire broom, in a transverse direction and penetrating the finished surface approximately 1/4 inch + 1/16 inch– 1/8 inch) at a maximum spacing of 1 -1/2 inches.

Immediately after final concrete placement and surface finishing, protect the concrete surface with a suitable enclosure until application of live steam or radiant heat. Assure the enclosure's ambient temperature is at least 50 °F. Assure the plastic concrete's temperature before initial set doesn't rise more than 10 °F per hour. Limit the total rise before initial set to less than 40 °F and the maximum temperature to 100 °F. Record the times and concrete temperatures before initial set.

For curing with low-pressure steam, do not apply live steam directly onto the concrete forms if it causes localized high temperatures.

For accelerated curing with radiant heat, apply radiant heat using pipes circulating steam, hot oil, or hot water, or using electric heating elements. Minimize moisture loss by covering all exposed concrete surfaces with plastic sheeting, 705.06, or by applying a liquid membrane curing compound, 705.07, to all exposed concrete surfaces. Before bonding field-cast concrete or other materials in the finished structure, remove the curing compound from the shear faces of composite members and other surfaces.

Start initial application of the steam or heat 2 to 4 hours after final concrete placement. If using retarders, start applying the steam or heat 4 to 6 hours after final concrete placement. If determining the time of initial set according to ASTM C 403, these time limits do not apply. Record and report the actual time of concrete placement of the last load, placement of enclosure and initial set time.

Apply live steam or radiant heat so the ambient temperature within the curing enclosure does not gain more than 40 °F per hour until reaching the curing temperature. Do not exceed 160 °F. Only use a maximum temperature of 180 °F if the fabricator documents to the City that delayed ettringite or alkali silica reaction is not at issue. Maintain the maximum curing temperature until the concrete has reached the required release strength. De-tension the strands immediately upon completing the accelerated curing. Keep a record of the time the application of heat began, and curing temperatures throughout the entire curing process.

Neatly fill cavities in the exposed surface of beams with nonshrink grout. Clean the concrete, and apply and cure the grout according to the manufacturer's published recommendations. Reject beams with honeycombing that impairs the member's performance.

515.16 Release of Prestressing Strands. Do not release prestressed strands until the concrete reaches a minimum strength of 4000 pounds per square inch, or plan defined release strength. Determine strength of concrete by testing cylinders produced according to AASHTO T 23 and cured in the same method as the member. Test cylinders in the fabricator's laboratory. Assure all tested cylinders obtain the required strength of 4000 pounds per square inch or the plan defined release strength. Provide the City the ability to witness the cylinder testing by notifying the inspector before testing.

Before releasing prestressed strands, loosen or remove forms and hold-downs and all other attachments restricting either horizontal or vertical movement of prestressed members. Release the strands immediately upon completing accelerated curing. Heat release and burn the strands simultaneously between each beam and at all exposed points between anchorages, and follow an approved pre-determined pattern, to equalize the forces being transferred to the various areas of the cross-section of the member. Submit any alternative strand release plans during the prefabrication meeting to Engineer for approval. For heat release, use a low-oxygen flame to uniformly heat at least a 4 inch long section of strand before completely cutting the strand.

515.17 Fabrication Tolerances. Construct all members to conform to the following tolerances.

BEAM DIMENSIONAL TOLERANCES

Description	Box Beam	I Beam
Length of beam	±1/8" per 10 ft max ±3/4"	±1/8" per 10 ft max ±1"
Depth of beam	±1/4"	-1/4" +1/2"
Depth of I beam flange including fillets	N/A	±1/4"
Beam (box)/Flange (I) Width	±1/4"	-1/4" +3/8"
Flange Thickness excluding fillets		
a) Top	-0 +1/2"	±1/4"
b) Bottom	-1/8" +1/2"	±1/4"
Width Web	N/A	-1/4" +3/8"
Width beam walls	-1/4" +3/8"	N/A
Width of Void	±1/2"	N/A
Height of Void	±1/2"	N/A
Box Beam Diaphragm spacing	±2"	N/A
Deviation from True Vertical	±1/8"	1/8" per ft
Deviation from Skew Angle	±1/2"	±1/2"

BEAM ACCESSORY TOLERANCES

Description	Box Beam	I Beam
Position of railing anchors	±1/4"	N/A
Position of lifting devices	±6"	±6"
Positions of anchor dowels and tie rods, inserts	±1/2"	±1/2"
Deviation from skew angle	±1/2"	±1/2"

BEAM STRAND TOLERANCES

Description	Box Beam	I Beam
Strand tendon position	±1/4"	±1/4"
Strand CG position	±1/4"	±1/4"

REINFORCING STEEL TOLERANCES

Description	Box Beam	I Beam
Clear cover	-0 +1/4"	-0 +1/4"
Splice lengths	-1 1/2"	-1 1/2"
Stirrup spacing in anchorage zone	±1/4"	±1/4"
Stirrup spacing outside anchorage zone	±1"	±1"
Stirrup extension above top flange	-1/2" +1/4"	0 +1”
Reinforcement extension beyond beam end	-3/4" +0	-3/4" +0

BEAM SWEEP AND CAMBER TOLERANCES

Description	Box Beam	I Beam
Horizontal Sweep	±1/8" per 10 ft max ±3/4"	±1/8" per 10 ft max ±1"
Max Gap between beam	1"	N/A
Deviation from Design camber (Dt) [1]	±+ Sacrificial Haunch [2] or 1/8” per 10 ft max ±1/2”	max ± 1” + Sacrificial Haunch[2] or
Variation in camber between beams in same span	max 1/2"	N/A

[1] Design camber (Dt) calculated in accordance with 511.07.
[2] Unless otherwise noted, Sacrificial Haunch thickness is 2”.

515.18 Prestressed Member Acceptance and Repair. Throughout the fabrication process reject all prestressed members not meeting specification requirements.

For all rejected members provide the City with a complete description of the rejection, and unless waived by the Engineer, an Ohio registered professional engineer's written evaluation of the criticalness of the rejection and the professional engineer's proposed repair method that will repair the rejected member to an acceptable condition. The City will determine the acceptability of the member and the repair procedure. If acceptable, the fabricator will only make repairs witnessed by the City's inspector unless waived by the Engineer.

Use the Precast/Prestress Concrete Institute's Manual for the evaluation and repair of Precast, Prestressed Concrete Bridge Products MNL-137-06 as a general guide.

The City will not accept for shipping, prestressed members with measured camber exceeding the Design Camber (Dt), used to establish the seat elevations, according to 511.07, by more than the Sacrificial Haunch thickness, until a corrective work plan has been approved by the Engineer. The plan shall be signed, sealed and dated by an Ohio Registered Engineer and shall include all revised plan information necessary to place the deck to the plan thickness. If the prestressed members are acceptable, exclusive of the deviation from Design Camber, the City will pay for all costs incurred resulting from measured camber exceeding Design Camber calculated for the actual beam age at the time of deck placement, as Extra Work, 109.05.

515.19 Handling Storage, Transportation, and Erection. Handle, store, transport, and erect the members in an upright position. The direction of support reactions during storage and transportation shall be the same as the member will experience in its in-service position. Do not ship prestressed members until the concrete obtains its 28-day design strength and the inspector's approval.

Provide at least 30 inches horizontally between each beam for inspection. Provide at least 8 inches of vertical clearance from the bottom. Use storage support locations as close as practical to the in-service support locations. During storage, provide unyielding horizontal supports and bracing capable of maintaining the members in a vertical position.

Transportation support locations shall be the sole responsibility of the fabricator with respect to member stresses and safe delivery to the job site. If it is necessary to transport the members in a position other than vertical, obtain the Engineer's written approval.

Provide lifting devices capable of withstanding the required loads to lift and erect the members. During erection, accurately place the prestressed beams on their bearings to ensure a uniform load on all bearings. When shifting a member, lift the member up completely off of its bearings. Temporarily brace the first I-beam erected to its substructure support units in the vertical position before releasing the beam from the crane. Tie each subsequent I- beam to the previously braced beam(s). Provide bracing after erection adequate to prevent sliding, tipping, or other movement that may result from high winds, creeping down the grade, or other causes, until placement of the diaphragms. Within any one day erect and brace at least 2 adjacent members in any one span before suspending operations for the day.

Place box beams to ensure a correct fit of the keyways and to ensure proper grouting of the keyways. After placing the beams and installing tie devices, fill the longitudinal keyways using non-shrink keyway grouts, 705.22, approved by the Engineer. Mix, install, and cure the grout according to the manufacturer's published recommendations to obtain a design compressive strength of 5000 pounds per square inch.

Do not allow vehicular load on an individual prestressed concrete box beam until the grout in the keyway obtains the specified design strength of 5000 pounds per square inch.

At the Engineer's discretion, repair or replace members damaged by improper handling, storage, transportation, or erection.

515.20 Safety Requirements. Provide effective safety measures to prevent injuries to personnel due to breakage of strands or failure of anchorage devices during the tensioning operations. Provide adequate protection and assure the City inspector can perform inspection of beams and manufacturing processes. The City inspector will report any inadequate safety precautions to the plant QCS and to the Engineer if fabricator remedial action is not taken. City inspectors will follow safety rules established by the fabricator, at a minimum. Where fabricator safety rules interfere with the inspectors' duties, the process should be altered to allow the inspections to be performed while maintaining the required level of safety.

515.21 Method of Measurement. The City will measure Prestressed Concrete Bridge Members by the number of members.

The City will measure the intermediate diaphragms by the number of each placed.

515.22 Basis of Payment. Payment for prestressed concrete beams include all inserts, sleeves, fittings, reinforcing steel fully or partially encased in the members, threaded rods, embedded inserts, embedded bearing sole plates, temporary bracing, fixed anchor dowels, and all transverse tie rods necessary to complete this work. The City will consider all costs associated with all structural steel, including bolts, nuts, washers and plate washers for steel intermediate diaphragms, as well as concrete and reinforcing steel for cast-in-place concrete intermediate diaphragms as incidental to the intermediate diaphragms.

The City will pay for expansion joint end diaphragms, semi-integral diaphragms, pier diaphragms, bearing load plates, bearing pads, and other expansion materials separately.

The City will not pay for repaired or replaced members damaged by improper handling, storing, transporting, or erecting.

The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
515	Each	Prestressed Concrete Non- Composite Box Beam Bridge Members, Level 1
515	Each	Prestressed Concrete Composite Box Beam Bridge Members, Level 1

515	Each	Straight Strand Prestressed Concrete Bridge I-Beam Members, Level 2
515	Each	Draped Strand Prestressed Concrete Bridge I-Beam Members, Level 3
515	Each	Intermediate Diaphragms

ITEM 516 EXPANSION AND CONTRACTION JOINTS, JOINT SEALERS AND BEARING DEVICES

516.01 Description
516.02 Fabrication
516.03 Coating
516.04 Materials
516.05 Expansion and Contraction Joints
516.06 Joint Sealers
516.07 Bearing Devices
516.08 Method of Measurement
516.09 Basis of Payment

516.01 Description. This work consists of fabricating, assembling, constructing, coating, and installing expansion and contraction joints, vertical extension of structural expansion joints, joint sealers, or bearing devices of the type and size specified.

516.02 Fabrication. Fabricate metal joint armor and metal bearings according to Item 513. Select a fabricator that is at least pre-qualified at level SF. The City will base final acceptance of fabricated members on the Engineer's approval that the fabricated items that can be successfully incorporated into the structures. Submit mill test reports for structural steel, steel castings, bronze, and sheet lead certified according to 501.06.

516.03 Coating. Coat exposed steel bearings according to Items 513 and 514 that are to be attached to structural steel. Galvanize bearings according to 711.02 that are to be attached to concrete beams.

Coat metal parts of expansion joints with metalized 100 percent zinc wire. Prepare the surface to be coated and apply coating as required by The Society of Protective Coatings SSPC-CS-23.00(1). Apply coating to a minimum thickness of 6 mils.

Repair metalized coatings damaged during fabrication by removal of the damaged coating and reapplication as specified above. Repair metalized or galvanized coatings damaged during shipping, construction, or field welding according to 711.02.

516.04 Materials. Furnish materials conforming to:

Structural steel..... 513
Bearing bolts and anchor rods..... 711.10
Painting 514
Joint sealer, hot applied..... 705.04
Preformed elastomeric compression seal..... 711.33
Elastomeric strip seal 711.32
Neoprene Sheeting 705.13
Steel castings..... 711.07
Sheet copper..... 711.15
Bronze 711.16, 711.17, 711.18
Sheet lead. 711.19
Preformed bearing pads..... 711.21
Elastomeric bearings 711.23
Preformed fillers..... 705.03
Swedged anchor bolts or bars*..... 711.10
Non-Shrink, Non-Metallic Grout 705.20

* Fabricated by deforming a minimum of 20 percent of the embedded bolt surface with deformations whose radial dimensions are 15 to 20 percent of the bar diameter.

516.05 Expansion and Contraction Joints. Ensure that expansion joints are completely open for the dimension specified for their full length. Remove stones, forms, or other materials that interfere with expansion.

Finish the surface adjacent to preformed expansion joints to a smooth, uniform surface. Use methods that do not interfere with the free compression of the joint material to anchor the expansion joint materials. The joint material shall neatly fill the space, and have a uniform thickness for the full extent of the joint.

Preformed elastomeric strip seals shall be installed according to the manufacturer's specifications and as specified herein. The top of the steel edge support rails shall be smooth and free of burrs. Preparation and placement of the gland will only be allowed after the anchoring material has fully cured. Prior to placement of the strip seal, the cavity shall be cleaned of debris. The steel extrusion cavities shall be kept clean and dry until the strip seal is placed. The placement of the strip seal will only be permitted when the ambient air and steel substrate temperatures are above the minimum temperature recommended by the manufacturer. Prior to inserting the strip seal in the steel retainer cavities, the "locking ears" portion of the seal shall be coated with adhesive/lubricant. A maximum of 5 ft of gland shall be coated at a time to prevent the lubricant/adhesive from

drying prior to insertion into the cavities of the steel locking edge rails. After each section is coated, the coated portion of the seal shall be inserted in the steel locking edge rail cavities.

For Integral and Semi-Integral Abutment Expansion Joint Seals, install a 3 foot wide neoprene sheet for waterproofing of the backside of the joint between the integral backwall and the bridge seat at locations shown in the plans. Secure the neoprene sheeting to the concrete with 1 1/4 inch by #10 gage (length × shank diameter) galvanized button head spikes through a 1 inch outside diameter, #10 gage galvanized washer. Maximum fastener spacing is 9 inches. Use of other similar galvanized devices, which will not damage either the neoprene or the concrete, will be subject to the approval of the Engineer.

Center the neoprene strips on all joints. For horizontal joints, secure the horizontal neoprene strip by using a single line of fasteners, starting at approximately 6 inches from the top of the neoprene strip. For the vertical joints secure the vertical neoprene strip by using a single vertical line of fasteners, starting at approximately 6 inches from the vertical edge of the neoprene strip nearest to the centerline of roadway.

For vertical joints, install two additional fasteners at 6 inches, center to center, across the top of the neoprene strip on the same side of the vertical joint as the single vertical row of fasteners is located. The vertical neoprene strips shall completely overlap the horizontal strips. Lap lengths of the horizontal strips that are not vulcanized or adhesive bonded, shall be at least 1 foot in length, or 6 inches in length if the lap is vulcanized or adhesive bonded. No laps are acceptable in vertically installed neoprene strips. The neoprene sheeting shall be 3/32 inch thick general purpose, heavy-duty neoprene sheet with nylon fabric reinforcement.

516.06 Joint Sealers. Before applying joint sealer to the surface, clean the concrete of foreign matter, curing compounds, oil, grease, dirt, free water, and laitance and clean steel by sand blasting.

Apply joint sealer with a minimum depth of 1 inch at its thinnest section. Fill joints to within 1/4 inch of the roadway surface.

Separate joint sealer from contact with asphalt concrete using a barrier of foil or other material that is impervious to the joint sealer.

As required to prevent bonding of the joint sealer with a joint surface, place a suitable bond breaker barrier before applying the joint sealer.

Remove joint sealer that did not bond to the joint face as intended within 24 hours after placing. Clean the joint by sandblasting and reseal the joint.

Mix and place joint sealer according to the manufacturer's instructions. Provide the Engineer with a copy of the manufacturer's instructions.

Protect joint sealer with an impervious masking tape during the application of concrete protective coatings containing mineral spirits.

516.07 Bearing Devices. For sliding plates, lubricate the sliding surfaces with flake graphite, and superimpose plates on each other with their edges flush.

Install each bridge bearing to within ± 0.125 inch of its marked centerlines in the horizontal plane and oriented to within an angular tolerance of 0.20 rad.

Accurately set, level and align elastomeric bearings, bearing plates, and bolsters. Set bearing plates and bolsters on 0.125 inch thick sheet lead, conforming to 711.19.

Set bearing plates or bolsters on bridge seat areas that are flat and smoothly finished. If the bridge seat area is high or uneven, use a bushhammer or grinder followed by thin film of portland cement mortar or paste to fill the pitted surface to bring the seat area to the proper elevation and provide a level, even surface. If the bridge seat area is low, use steel plate shims of the same bearing area as the bearing plates and bolsters to bring the seat area to the proper elevation.

Set elastomeric bearing pads directly on the concrete surface. If the beams seats are sealed with an epoxy or non-epoxy sealer prior to setting the bearings, do not apply sealer to the concrete surfaces under the proposed bearing locations. If these locations are sealed, or membrane cured, remove the sealer or membrane cure to the satisfaction of the Engineer before setting the bearings. Perform this removal at no expense to the City.

Position rockers, elastomeric bearings, and rollers so that, when the completed bridge is at 60 °F, the rockers and elastomeric bearings are vertical and the rollers are centered on the base. If the steel is erected at an ambient temperature higher than 80 °F or lower than 40 ºF and the bearing shear deflection exceeds 1/6 of the bearing height at 60 ºF ± 10 ºF, raise the beams or girders to allow the elastomeric bearings to return to their undeformed shape at 60 ºF ± 10 ºF.

Set anchor bolts for bearing devices that are clear of the beam or girder flanges, in the concrete after erecting the main structural steel, except as specified below for bearing devices at abutments. Place reinforcing steel in the bridge seat to not interfere with the drilling of anchor holes. Accurately set anchor bolts in the holes and embed the anchor bolts in non-shrink, non-metallic grout. Until the anchors' are installed, prevent water from entering and or freezing in the anchor bolt holes.

If structural steel interferes with the setting of the anchor bolts, set the anchor bolts before erecting the steel. The Contractor may determine the location of the bolts by using a template and form holes or embed the bolts when placing concrete or, drilling holes in the hardened concrete.

Install anchor bolts to project at least ¼ inch beyond the nut when tightened. Damage or burr the threads on the projecting end of the bolt after the nut is tightened. The bolt threads shall not extend to the planes of the contact surfaces between the connected parts. Include the length of two additional threads to the specified thread length of the bolt to allow for thread runout. Washers no thicker than ¼ are permitted under the nut.

Permanently fasten bearing devices to the abutments, steel beams, or girders after backfilling the abutments to within 2 feet of the top of the bridge seat.

Where the load plate of an elastomeric bearing is to be connected to the structure by welding, control the welding so that the plate temperature at the elastomer bonded surface does not exceed 300 °F as determined by use of pyrometric sticks or other temperature monitoring devices.

516.08 Method of Measurement. The City will measure the specified items by the number of each, square feet, pounds, or feet horizontally along the joint centerline and between the outer limits of the fabricated joint.

For deck resurfacing, the City will measure Structural Steel Expansion Joints extending vertically by the actual horizontal length of joint.

516.09 Basis of Payment. The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
516	Foot, or Pound	Structural Steel Expansion Joints
516	Foot	Structural Expansion Joints Including Elastomeric ___ Seals
516	Foot	Elastomeric Compression Seals for Structural Steel Joints, ___ Width
516	Foot	Elastomeric Strip Seals for Structural Steel Joints, ___ Width
516	Foot	Folder Copper Strip ___
516	Foot	Vertical Extension of Structural Expansion Joints
516	Square Foot	___ Preformed Expansion Joint Filler
516	Foot	Joint Sealer
516	Each, Foot, Square Foot, or Pound	Bearing Devices
516	Each, Square Foot	___ inch Elastomeric Bearing Pad
516	Each	Elastomeric Bearing with Internal Laminates Only
516	Each	___ × ___ × ___ Elastomeric Bearing with Internal Laminates and Load Plate ___ × ___ × ___
516	Square Foot	1/8-inch Preformed Bearing Pads

ITEM 517 RAILINGS

517.01 Description
517.02 Fabrication
517.03 Materials
517.04 Construction Methods, General
517.05 Steel and Iron Railings
517.06 Aluminum Railings
517.07 Method of Measurement
517.08 Basis of Payment

517.01 Description. This work consists of furnishing, constructing, coating, and erecting the type of railing specified. This work also consists of providing and galvanizing structural posts, anchors, and connections.

517.02 Fabrication. Fabricate railing according to Item 513. Select a fabricator that is at least prequalified at level SF. The City will base final acceptance of fabricated members on the Engineer's approval that the fabricated items that can be successfully incorporated into the structures. Submit mill test reports for structural steel, steel castings, bronze, and sheet lead certified according to 501.06.

517.03 Materials. Furnish materials conforming to:

Concrete, Class COC 2..... 499, 511
Reinforcing steel 509, 709
Structural steel..... 513
Preformed fillers
(sponge rubber or PVC)..... 705.03
Steel tubing 707.10
Paint 708
Metal deep beam rail 710.06
Ductile iron casings..... 711.13
Aluminum 711.20
Timber..... 711.26
Stainless steel fasteners. 730.10
Pipe 707.70

Submit mill test reports for structural steel and aluminum according to 501.06.

517.04 Construction Methods, General. Construct railings as shown on the plans. Install posts for metal railings normal to the grade line. Install the tops of railings parallel to the grade line.

Remove or release shoring or falsework supporting the superstructure before placing railing that has no expansion joints or that is on the concrete parapet.

517.05 Steel and Iron Railings. Unless specified to paint according to Item 514, galvanize all parts of steel and iron railings.

Erect metal deep beam rail elements according to Item 606.

517.06 Aluminum Railings. Use alloy conforming to 711.20 for aluminum railings.

Give the extreme outer surfaces of cast railing posts a 40-grit finish. The Contractor is not required to provide a special finish for other portions of railings. Do not scratch, dent, or cause other damage to railings that may affect the durability or appearance of the railing.

Use galvanized steel anchor bolts and hexagon nuts conforming to 711.02. Coat the entire projecting portion of anchor bolts and fill the space between the bolts and post base with an aluminum-impregnated caulking compound.

Where aluminum contacts concrete or stone masonry, thoroughly coat the contact surfaces with an aluminum-impregnated caulking compound or with a heavy asphalt material paint pigmented with aluminum powder or paste thereby providing an aluminum appearance. Where aluminum or aluminum shims contacts different metal, thoroughly coat the contact surface with an aluminum-impregnated caulking compound or place a synthetic rubber impregnated fabric gasket between the metals.

Weld only where shown on the plans using inert gas shielded metal-arc or tungsten-arc method without flux, or by other approved methods.

517.07 Method of Measurement. The City will measure Railing by the number of feet of railing including end posts. If deep beam guardrail is used, the City will measure the length of railing between the first posts off the bridge excluding the first posts off the bridge. If hand rails or tubular backup rails are used, the City will not measure any portions extending beyond the first posts off the bridge. If twin steel tube bridge railing is used, the City will measure the length of the railing between the second post off the bridge including the second post.

517.08 Basis of Payment. The cost of hand rails or tubular backup rails extending beyond the measured limits are included for payment in the unit price bid for the measured length.

The City will pay for accepted quantities at the contract price as follows:

Item	Unit	Description
517	Foot	Railing (___)

ITEM 518 DRAINAGE OF STRUCTURES

518.01 Description
518.02 Fabrication
518.03 Materials
518.04 General
518.05 Porous Backfill
518.06 Pipe
518.07 Scuppers
518.08 Excavation
518.09 Method of Measurement
518.10 Basis of Payment

518.01 Description. This work consists of constructing drainage systems.

518.02 Fabrication. Fabricate scuppers according to Item 513. Select a fabricator that is at least pre-qualified at level SF. The City will base final acceptance of all fabricated members on the Engineer's approval that the fabricated items can be successfully incorporated into the structures. Submit mill test reports for structural steel, steel castings, bronze, and sheet lead certified according to 501.06.

518.03 Materials. Furnish materials conforming to:

Scuppers, structural steel and cast steel 513
Metal pipe 707
Plastic pipe 720.12, 720.08
Other metals 711
Geotextile fabric, Type A 712.09

Furnish pipe specials of a grade at least as high as the type of pipe specified.

Furnish porous backfill consisting of gravel or stone, with a No. 57 size gradation according to Table 703.01-1. The sodium sulfate soundness loss shall not exceed 15 percent.

518.04 General. As shown on the plans, connect all parts to new or existing sewers or other outlets.

When installing to superstructure, take into account the deflection of spans under full dead load.

518.05 Porous Backfill. Place porous backfill as shown on the plans. When not shown on the plans, place backfill at least 2 feet thick behind the full length of abutments, wing walls, and retaining walls. Measure the thickness of porous backfill normal to the abutment or wall face. The

Contractor may leave undisturbed rock or shale within 18 inches of the abutment or wall. Place 2 ft^3 of bagged No. 3 aggregate at each weep hole to retain the porous backfill. Place the porous backfill for the full width of the trench and extend it to the bottom of the approach slab or base, as shown in the plans. Place porous backfill in loose lifts not to exceed 12 inches. Run a plate compactor or tamper over the top of each lift for consolidation of approximately 85% of original layer thickness. If placed in loose lifts greater than 12 inches, flood the porous backfill at the appropriate moisture content for consolidation of approximately 85% of original layer thickness.

518.06 Pipe. For drain pipe leading down from the superstructure, use either galvanized steel pipe, 707.70; or plastic pipe, 720.08. Provide specials, elbows, tees, wyes, and other fittings essential for a complete and satisfactory installation of the same material and quality as the pipe. Construct watertight joints of adequate strength. In steel pipe, weld joints or use clamp-type couplings having a ring gasket. In plastic pipe, make joints according to the applicable ASTM standard. In reinforced thermosetting resin pipe, make joints according to manufacturer guidelines and procedures. Securely fasten the pipe to the structure with hanger or clamp assemblies that are galvanized according to 711.02.

Place subsurface pipe as shown in the plans. If the plans require drainage pipe in the porous backfill, provide plastic pipe conforming to 720.12.

For corrugated metal pipe, perforated specials are not required and the Contractor may make bends with adjustable elbows conforming to the thickness requirements of the pipe specifications.

518.07 Scuppers. Construct secure and watertight connections, including the connections to adjacent concrete. Provide castings, true to form and dimension. Weld the joints of structural steel scuppers. Galvanize scuppers according to 711.02.

518.08 Excavation. Excavate all material encountered to the dimensions necessary to provide ample space at least to install pipe or other drainage facility behind abutments and for outlets.

518.09 Method of Measurement. The City will measure Porous Backfill and Porous Backfill with Geotextile Fabric by the number of cubic yards or lump sum. The City will measure pipe specials by the same method as the pipe. If pipe is by the foot, the City will measure the pipe along its centerline.

518.10 Basis of Payment. The cost to backfill, if not separately itemized in the Contract, and excavation is incidental to the drainage facility that necessitates them.

The City will include bagged aggregate with porous backfill for payment.

The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
518	Cubic Yard or Lump Sum	Porous Backfill
518	Cubic Yard or Lump Sum	Porous Backfill with Geotextile Fabric
518	Foot	___ inch ___ Pipe, Including Special
518	Each	Scuppers, Including Supports
518	Pound or Foot	Trough Horizontal Conductors
518	Pound or Foot	Pipe Horizontal Conductors
518	Foot	___ inch Pipe Downspout Including Specials

ITEM 519 PATCHING CONCRETE STRUCTURES

519.01 Description
519.02 Materials
519.03 Removal of Disintegrated Concrete
519.04 Preparation of Surface
519.05 Placing of Reinforcing Steel
519.06 Placing, Finishing, and Curing of Concrete
519.07 Method of Measurement
519.08 Basis of Payment

519.01 Description. This work consists of removing all loose and disintegrated concrete; preparing the surface; furnishing and placing reinforcing steel including welded steel wire fabric, dowels, and expansion bolts; placing forms; and placing concrete patches, including curing of same.

519.02 Materials. Furnish materials conforming to:

Concrete, Class COC 5..... 499, 511
Dowels ..... 709.01, 709.03, or 709.05
Reinforcing steel 509
Welded steel wire fabric..... 709.10 or 709.12

519.03 Removal of Disintegrated Concrete. Remove all loose and disintegrated concrete from the areas to be repaired in such a manner and to such an extent as to expose a sound concrete surface. Provide patches at least 4 inches deep, except on top horizontal surfaces, provide patches

at least 3 inches deep. Remove sound concrete (beneath the disintegrated concrete) for a depth of not less than 1/4 inch and not more than 1 inch, provided that the above minimum depth of patch is maintained. Make square or, preferably, slightly undercut shoulders having a depth of not less than the specified minimum depth of the patch at the edges of all patches.

Only use pneumatic or hand tools that give results satisfactory to the Engineer in the removal of the disintegrated concrete and in preparing and shaping the areas to be patched.

If working around reinforcing steel, avoid damaging or debonding any reinforcing steel that is un-corroded and completely embedded in sound concrete. Ensure there is no shattering of the concrete, beyond the area to be patched. If the area around the reinforcing steel is either embedded in unsound concrete or the reinforcing steel is exposed during removal, continue to remove the concrete around the reinforcing steel to completely expose the reinforcing and provide at least a 1 inch clearance around the reinforcing.

Adequately support reinforcement that is loose, and tie it back into place. Replace reinforcement damaged during removing concrete.

519.04 Preparation of Surface. After removing all disintegrated and loose concrete, properly shape the area to be patched, and install dowels or expansion bolts as necessary to hold the wire fabric to be used in the patch. Thoroughly clean the surface of the area to be patched and all exposed reinforcing steel of all dirt, dust, or other foreign materials with water, air under pressure, or any other method that produces satisfactory results. Thoroughly drench the surface with clean water. Before placing the concrete, allow the surface to dry to a damp condition.

519.05 Placing of Reinforcing Steel. The City will not require reinforcement for patches on top horizontal surfaces. Reinforce patches on other surfaces with welded steel wire fabric either 2 × 2 inch using wire size number W 0.9, or 3 × 3 inch using wire size number W 1.4. Cover the entire area of the patch with the fabric, and place and hold the fabric approximately 1 inch from the completed exposed surface of the patch. Securely fasten the fabric to the reinforcing steel in the original structure exposed in removing the disintegrated concrete. If no reinforcing steel is exposed or it is not practical to fasten the fabric to exposed steel, install dowels or expansion bolts at a distance not to exceed 18-inch centers in both directions, and fasten the fabric to these dowels or bolts.

519.06 Placing, Finishing, and Curing of Concrete. Place and finish Class COC 5 concrete according to Item 499 and 511.

Remove the forms within 24 hours after placing the concrete, and finish all exposed surfaces by rubbing to match the surrounding concrete. Apply membrane curing according to 511.14, Method B, immediately after rubbing the surfaces.

After curing and before final acceptance, sound all patched areas. Remove and replace all unsound or visibly cracked areas.

519.07 Method of Measurement. The City will measure Patching Concrete Structures by the number of square feet of the exposed surfaces of all completed patches, irrespective of the depth or thickness of the patch. If a patch includes corners or edges of members such as beams, curbs, and columns, the City will measure all of the exposed surfaces. If a patch extends completely through a member of a slab, the City will measure both exposed surfaces.

519.08 Basis of Payment. The City will pay for accepted quantities at the contract price as follows:

The City will not pay for replacing reinforcement damaged during concrete removal.

The City will not pay for removing and replacing of patched areas that are unsound or visibly cracked.

Item	Unit	Description
519	Square Foot	Patching Concrete Structures

ITEM 520 PNEUMATICALLY PLACED MORTAR

520.01 Description
520.02 Materials
520.03 Removal of Concrete
520.04 Reinforcement
520.05 Preparation of Repair Area
520.06 Mixing
520.07 Proportions
520.08 Pressures
520.09 Preconstruction Testing
520.10 Placing
520.11 Inspection and Testing
520.12 Method of Measurement
520.13 Basis of Payment

520.01 Description. This work consists of repairing the surface of concrete structures using pneumatically placed mortar where the depth of repair generally is less than 6 inches.

520.02 Materials. Furnish materials conforming to:

Reinforcing steel 509
Portland cement..... 701.01 through 701.05, 701.09
Fine aggregate 703.02, 703.03

Welded steel wire fabric..... 709.10 or 709.12

Use water free from sewage, oil, acid, strong alkalis, vegetable matter, clay, and loam. Potable water is satisfactory for use in mortar.

520.03 Removal of Concrete. In areas to be repaired, remove all loose, soft, honeycombed, and disintegrated concrete, plus a 1/4-inch depth of sound concrete. Remove additional concrete as necessary to permit the placement of the minimum specified mortar thickness of not less than 1 ½ inches, except on top horizontal surfaces where it shall not be less than 3/4 inch. Perform all work in such a manner as not to damage or shatter the concrete that is to remain in place. Make square or, preferably, slightly undercut shoulders at the edge of all repair areas.

Encase reinforcing bars exposed after concrete removal, as required above, with pneumatically placed mortar. If these bars are less than 1 inch from the proposed finished surface of mortar, drive them back, if practical, into recesses cut in the masonry to obtain that coverage. If this is impractical because of large concentrations of reinforcing bars, provide the minimum specified mortar coverage by modifying the finish surface as the Engineer approves.

If the bond between the concrete and a primary reinforcing bar has been destroyed, or if more than one-half of the periphery of a bar has been exposed, remove the adjacent concrete to a depth that will provide a minimum 3/4-inch clearance around the bar, except where other reinforcing bars make this clearance impractical. Adequately support reinforcing that has become loose, and tie it back into place. Replace reinforcement that is damaged during construction operations.

Only use pneumatic or hand tools that give results satisfactory to the Engineer in the removal of concrete and in preparing and shaping the areas to be repaired.

If working around reinforcing steel, avoid loosening the steel, or shattering the concrete around it, beyond the repair area.

520.04 Reinforcement. If pneumatically placed mortar is specified to repair areas of unsatisfactory concrete, or for surface coverage of exposed reinforcing steel, place wire fabric in all areas where the thickness of the mortar patch is 1 ½ inches or more. For areas where the thickness of the mortar patch exceeds 4 inches, use a single layer of wire fabric to reinforce each 4-inch thickness of patch or fractional part thereof. Use fabric that is either 2 × 2 inches using wire size number W 0.9, or 3 × 3 inches using wire size number W 1.4. Place all fabric parallel to the proposed finished surface. Completely encase each layer of fabric in mortar that has taken its initial set before the succeeding layer of fabric is applied. Ensure that fabric supported adjacent to the prepared masonry surface is no closer than 1/2 inch to that surface. Overlap adjacent sheets of fabric by 6 inches, and securely tie them together. Carefully pre-bend fabric before installation to fit around corners and into re-entrant angles. Never spring fabric into place.

Place all steel items, including reinforcing bars and wire fabric, no closer than 1 inch to the proposed finished surface of mortar.

Support wire fabric with anchor bolts except where existing reinforcing steel in the repair area is considered by the Engineer to be satisfactory for this purpose. Construct anchors of 1/4-inch minimum diameter expansion hook bolts, and ensure that each bolt has sufficient engagement in sound masonry. For repairs that are generally 4 inches thick or less, space anchors no more than 12 inches and 18 inches, center-to-center, on overhead and vertical surfaces, respectively, and 36 inches, center-to-center, on top horizontal surfaces. For repairs that exceed 4 inches in thickness, ensure that the anchor bolts are capable of supporting three times the weight of suspended mortar and two times the weight of mortar on vertical surfaces. Use at least three anchors for each patch.

If specified, thoroughly clean reinforcing exposed in the original structure, or exposed after removals as required above, and restore any appreciable reduction in steel area as directed.

520.05 Preparation of Repair Area. After removing all unsatisfactory concrete, properly shaping the sound concrete surface, placing dowels and expansion hook bolts, and restoring steel area as directed, and within 24 hours before placing the mortar, blast clean all surfaces to which the mortar is to bond, including exposed reinforcing steel, existing concrete, and the work face of any previously placed mortar, to remove all spalls, laitance, and contaminants detrimental to the achievement of an adequate bond. The Contractor may blast clean these surfaces using high-pressure water blasting with or without abrasives in the water, abrasive blasting with containment, or vacuum abrasive blasting. If a bonding compound is not specified, drench the prepared masonry surface with water and keep the prepared surface wet during the 2 hours preceding the placement of the mortar. Ensure that all surfaces are damp, but without free water, while placing mortar. The Engineer will approve the preparation and condition of all surfaces immediately before the application of the mortar.

520.06 Mixing. Thoroughly dry mix the materials in a batch mixer. Before placing the mixture in the hopper of the cement gun, remove all materials and lumps over 1/4 inch in size by screening.

Apply the screened sand and cement to the masonry surface within 1 hour after being combined.

520.07 Proportions. Ensure that the mixture as placed in the hopper has a ratio of one volume of portland cement to three volumes of sand.

520.08 Pressures. Use at least 35 pounds per square inch pneumatic pressure at the cement gun in placing the mixed material. If more than 100 feet of hose or a greater lift than 25 feet is used, increase the pressure proportionately. Maintain the water at a uniform pressure of not less than 25 pounds per square inch above the pressure of the air on the gage at the cement gun.

520.09 Preconstruction Testing. Before the start of placing any mortar, perform a preconstruction test to verify the operation of the equipment, to confirm the application crew's capability, and to ensure the pneumatically placed mortar will be of acceptable quality.

Fabricate the test panel by gunning mortar onto the plywood bottom of an open box 4-foot square and 4 inches deep. Install reinforcement in the test panel that matches the largest size and tightest spacing found for the reinforcement in the bridge. Mount the box vertically and apply the mortar using the same personnel, equipment, and procedures that will be used on the project, until the box is full. Adjust the mixing water to

provide mortar of the proper consistency, but do not exceed a total water content, including the free moisture in the aggregate and water added at the nozzle, of 4.5 gallons per sack of cement.

Take three cores from the test panel, and test them for compressive strength at an independent testing laboratory. Ensure that the strength at 28 days is a minimum of 4200 pounds per square inch or at a minimum compressive strength of 3200 pounds per square inch at 7 days.

After taking the cores, break the test panel and allow the Engineer to carefully examine the interior portions. Ensure that they are substantially free of hollow areas and sand pockets, and ensure that the mortar is well bonded to the reinforcement.

Have each crew proposed to perform this work fabricate a satisfactory panel before allowing that crew to apply mortar to the structure.

520.10 Placing. Place the premixed dry cement and sand by pneumatic equipment with the proper amount of water applied in the mixing nozzle for the correct placement consistency. Apply the mortar as dry as practical to prevent shrinkage cracking. Use shooting strips to ensure square corners, straight lines, and a plane surface of mortar, except as otherwise permitted by the plans or approved by the Engineer. Place shooting strips so as to keep the trapping of rebound at a minimum. At the end of each day's work, or similar stopping periods requiring construction joints, slope the mortar off to a thin edge. In shooting all surfaces, ensure that the stream of flowing material from the nozzle impinges as nearly as possible at right angles to the surface being covered, and hold the nozzle 2 to 4 feet from the working surface.

Apply a sufficient number of mortar coats to obtain the required thickness. Finish mortar repairs flush with the original masonry surface, except as noted for areas of exposed reinforcing steel. On vertical and overhead surfaces, do not apply any coat thicker than 1 inch, except as the Engineer approves, and place each coat so that it will neither sag nor decrease the bond of the preceding coat. If a successive coat is applied on mortar that has set for more than 2 hours, clean and dampen the mortar surface as required in 520.05 for the prepared masonry surface. Remove deposits of rebound from previous shooting, whether loose or cemented.

After mortar has been placed to the desired thickness, cut off all high spots with a sharp trowel, or screed them to a true plane as determined by shooting strips or by the original masonry surface, or as directed. If using screeds, apply them lightly to all surfaces so as not to disturb the mortar for an appreciable depth, and work them in an upward direction when applied on vertical surfaces. Unless otherwise directed, give the finished mortar surface a flash coat about 1/8 inch thick. Take special care to obtain a sightly appearance on all exposed surfaces.

Cover the pneumatically placed mortar patches with burlap or cotton mats, and keep them wet for 7 days after placing. If it is not practical to use mats, keep the surface wet by sprinkling for the same length of time. If the Engineer determines that the above curing procedures are impractical because of the inaccessibility of isolated repair areas, the Contractor may cure the final mortar surface according to 511.17, Method B. Do not place pneumatically placed mortar when the air temperature is below 50 °F or against a surface in which there remains any frost. Protect all mortar against cold weather according to 511.15.

520.11 Inspection and Testing. After curing and before final acceptance, sound all patched areas. Remove and replace all unsound or cracked areas. In addition to sounding all patches, the City will base acceptance of the pneumatically placed mortar on 4-inch diameter cores taken from patched areas and tested for compressive strength. The Engineer will determine the location of the cores, with one core being taken for each 200 square feet of pneumatically placed mortar. Drill the cores completely through the patched area and into the underlying sound concrete at least 1/2 inches. Ensure that the depth of the cores is at least 4 inches. The Engineer will visually inspect the cores at the site for hollow areas, sand pockets, and voids around reinforcing steel. Test the cores at an independent laboratory for compressive strength. The required minimum average compressive strength is 3000 pounds per square inch at 7 days, with no single core test less than 2600 pounds per square inch.

The Engineer will waive coring on small quantities or overhead patches if it is determined by sounding and visual inspection that the patches are sound.

Remove, replace, re-inspect, and re-test all defective patches, as determined by sounding, visible cracks, or unacceptable cores.

Fill core holes with concrete according to Item 519.

520.12 Method of Measurement. The City will measure Pneumatically Placed Mortar by the number of square feet as determined under Method A, unless Method B or another method is specified.

A. Method A. The City will measure the actual area of exposed surfaces of all completed, tested, and approved patches, irrespective of depth or thickness of the patch. If a patch includes corners or edges of such members as beams, columns, or curbs, the City will include all of the exposed surfaces; or if a patch extends completely through a member or a slab, the City will include both exposed surfaces.

B. Method B. For unreinforced mortar repairs, the City will measure the actual area of exposed surfaces of all completed, tested, and approved patches, irrespective of depth or thickness of patch. If a patch includes corners, or edges of such members as beams, columns, or curbs, the City will include all of the exposed surfaces. For fabric reinforced mortar repairs, the City will measure the actual surface area of fabric, complete and in place. The City will consider fabric laps and layers of fabric closer than 2 1/2 inches, center-to-center of layer, as a single layer in area measurements. The Contractor and the Engineer will agree on the measured area of wire fabric before said fabric is encased in mortar, otherwise the City will obtain the area of the patch for pay purposes as described for unreinforced mortar repairs.

The Contractor is responsible for all test panels, coring repair of core holes, independent laboratory testing of the cores, and replacement of rejected areas and shall include them under Pneumatically Placed Mortar.

520.13 Basis of Payment. The City will not pay for additional reinforcement to replace that damaged by the Contractor's operations.

The City will not pay for removing, replacing, and re-inspecting of defective patched mortar as determined by sounding, visible cracks, or unacceptable cores.

The City will pay for accepted quantities at the contract price as follows:

Item	Unit	Description
520	Square Foot	Pneumatically Placed Mortar

ITEM 522 STRUCTURAL PLATE CORRUGATED METAL STRUCTURES ON FOOTINGS

522.01 Description
522.02 Materials
522.03 General
522.04 Method of Measurement
522.05 Basis of Payment

522.01 Description. This work consists of furnishing structural plate corrugated metal structures of specified dimensions, including metal bearing angles or channels as required, and erecting same on concrete footings.

522.02 Materials. Furnish plates and bolts conforming to 707.03 or 707.23. Furnish steel bearing angles or channels conforming to 707.03 or 711.01. Furnish aluminum bearing angles or channels conforming to 707.23.

522.03 General. Properly support the metal bearing angle or channel in the position shown on the plans before placing footing concrete.

Erect the plates according to the manufacturer's assembly instructions. Hold the unsupported edges of all plates in position using temporary props. Progressively install a sufficient number of bolts to hold the plates in position. Do not tighten bolts until tightening will not interfere with the adjustment and matching of additional sections. If using drift pins or pry bars, take care to prevent chipping or injury to the galvanized coating. Tighten the bolts to a final minimum torque of 100 foot-pounds.

Within the limits of backfill, field coat the exterior of the 707.03 conduit above the limits of the bedding. The coating material and application shall conform to AASHTO M 243M. Thoroughly seal around all plate seams and bolts. Allow asphalt mastic material to dry for 48 hours and tar base material to dry for 28 hours before placing the conduit backfill.

Backfill according to the requirements for 603.08, Type A conduit.

522.04 Method of Measurement. The City will measure the actual number of feet of the corrugated metal structure, installed in place. The City will determine the length by taking the average of the two side measurements, end to end, at the point of bearing.

Excavation will be paid for under Item 203 or 503 as shown on the plans.

Concrete footings will be paid for as a separate pay item.

522.05 Basis of Payment. The City will pay for accepted quantities at the contract price as follows:

Item	Unit	Description
522	Foot	___' ___" Structural Plate Corrugated Metal Structure, ___-inch

ITEM 523 DYNAMIC LOAD TEST

523.01 Description
523.02 General
523.03 Equipment
523.04 Test Report
523.05 Basis of Payment

523.01 Description. This work consists of establishing a driving criteria for all the piles of a specified shape, cross-section, and ultimate bearing capacity or as specified on the plans to be installed in the structure. This shall be accomplished by applying dynamic loads with a pile hammer during driving of production piles to determine driving requirements. Apply the dynamic load to the piles using a pile hammer that is operating at its normal operating level. Perform restrike tests when specified in the plans

523.02 General. Perform dynamic tests on a minimum of two piles. Perform signal matching analysis of the dynamic test data on at least one of the two test piles. Perform the test according to ASTM D 4945 to determine driving requirements to achieve the required ultimate bearing values for the piles to be installed in the structure.

Perform restrike tests after piles have been driven and a minimum time specified in the plans has elapsed. When performing a restrike, warm the hammer before restriking the pile by applying at least 20 blows to another pile. Each restrike consists of performing dynamic testing on two piles and performing a signal matching analysis on one of the two piles tested.

Use the hammer selected for driving the test piles to drive all piles represented by the test piles. If the Contractor subsequently finds it necessary to use a different hammer or multiple hammers to drive piles represented by dynamic load testing, or if the hammer performance varies subsequent to the dynamic test, complete additional tests at no additional cost to the City.

523.03 Equipment. Supply all required dynamic testing equipment necessary to run the test set forth in ASTM D 4945. Supply personnel with an Advanced, Master, or Expert Level Certification in High Strain Dynamic Pile Testing (HSDPT) from either Foundation QA or the Pile Driving Contractors Association (PDCA) to operate this equipment. Supply the Engineer a copy of the certificate showing that personnel operating dynamic testing equipment are currently certified. Supply all personnel and equipment needed to strike the test piles with the pile hammer.

523.04 Test Report. Perform the dynamic test and signal matching analysis and immediately provide the Engineer driving criteria for any piles to be driven within the next 48 hours. Within 48 hours after performing the dynamic pile test or restrike tests, supply the Engineer with a written report confirming driving requirements for piles represented by the test. Include in the report, the required blow count for:

A. The different strokes of the ram at 6-inch intervals within the expected range of operation as determined by a wave equation analysis, when open ended diesel hammers and drop hammers are used.

B. The selected bounce pressures when closed end diesel hammers are used.

C. The operating air pressure and stroke when an air operated hammer is used.

D. The selected output energy or stroke when a hydraulic hammer is used.

Also include in the report a minimum depth of penetration if applicable.

Submit an electronic version of the report and data files from the testing and analysis to the Engineer.

523.05 Basis of Payment. The City will pay for dynamic load testing after being provided the written test at the contract price as follows:

Item	Unit	Description
523	Each	Dynamic Load Testing
523	Each	Restrike

ITEM 524 DRILLED SHAFTS

524.01 Description
524.02 Materials
524.03 Contractor's Installation Plan
524.04 Hole Excavation
524.05 Friction Type Drilled Shafts
524.06 Casings
524.07 Slurry
524.08 Excavation Inspection
524.09 Reinforcing Steel for Drilled Shafts
524.10 Concrete for Drilled Shafts
524.11 Free Fall Concrete Placement
524.12 Tremie
524.13 Pumped Concrete
524.14 Construction Tolerances
524.15 Inspection Records
524.16 Method of Measurement
524.17 Basis of Payment

524.01 Description. This work consists of furnishing and installing drilled shafts. The lengths of the drilled shafts shown on the plans are estimated from available subsurface information. Furnish the proposed drilled shafts according to plan requirements, with the understanding that the actual length required is based on conditions encountered during construction and may differ from the estimated length shown on the plans.

524.02 Materials. Furnish material conforming to:

Concrete, Class COC 4 or COC 5
for Mass Concrete..... 499, 511
Epoxy coated reinforcing steel 509

524.03 Contractor's Installation Plan. Submit, for the Engineer's acceptance, a written installation plan of procedures to follow when excavating the hole, placing the concrete, and monitoring the concrete placement. Submit the installation plan at least 14 Calendar Days before constructing the drilled shafts. Include the following information:

A. Details of the sequence proposed for the overall drilled shaft construction operation.

B. Procedures for maintaining correct horizontal and vertical alignment of the excavation.

C. If using a casing, method to advance the casing.

D. If using a temporary casing, details of the methods to extract the temporary casing and to maintain the concrete slump to keep concrete workable by adding admixtures such as retarders or superplasticizers.

E. If using slurry, details of the methods to mix, circulate, and de-sand the slurry. For polymer slurry, submit the manufacturer's recommendations for use of the slurry.

F. Details of methods to clean the shaft excavation.

G. Details of reinforcement placement including support and centralization methods.

H. Details of concrete placement including proposed operational procedures for free fall, tremie, or pumping methods.

I. A list of proposed equipment to be used such as cranes, drills, augers, bailing buckets, final cleaning equipment, de-sanding equipment, slurry pumps, tremies, concrete pumps, casings, etc.

Acceptance of the installation plan will not relieve the Contractor of the responsibility for obtaining the required results.

524.04 Hole Excavation. Take precautions to prevent damaging existing structures and utilities. Precautions include, but are not limited to, selecting construction methods and procedures that will prevent excessive caving of the shaft excavation, and monitoring and controlling the vibrations from the driving of casing or sheeting or drilling of the shaft.

When encountered, remove objects such as large boulders. Do not blast unless shown on the plans or authorized in writing by the Engineer.

Unless otherwise shown on the plans, where drilled shafts are to be installed in conjunction with embankment placement, construct shafts after the placement of the fill and completion of any specified settlement periods.

Excavate for the shafts to the dimensions and elevations shown on the plans. Use methods and equipment suitable for the intended purpose and materials encountered. Use either the dry method, wet method, temporary casing method, or permanent casing method as necessary to produce sound, durable concrete foundation shafts free of defects. When a particular method of construction is required on the plans, that method shall be used. If no particular method is specified for use, select and use a method based on site conditions.

If the excavation operation is stopped, protect the shaft cavity by installing a safety cover. The Contractor is responsible for the safety of the shaft excavation, surrounding soil, and the stability of the sidewalls. If necessary to ensure such safety and stability, use a temporary casing, slurry, or other methods accepted by the Engineer. Unless cased to the full depth, do not leave excavations unfilled overnight.

Use appropriate means, such as a cleanout bucket or air lift, to clean the bottom of the excavation of all shafts. Promptly notify the Engineer when unexpected obstructions are encountered.

A. Dry Construction Method. Use the dry construction method only at sites where the groundwater table and site conditions are suitable to allow construction of the shaft in a relatively dry excavation, and where the sides and bottom of the shaft remain stable without any caving, sloughing, or swelling and may be visually inspected before placing the concrete. The dry method consists of excavating the drilled shaft hole, removing accumulated water, and loose material from the excavation, and placing the shaft concrete in a relatively dry excavation. The rate of flow of water into the hole should not be more than 12 inches within a 1-hour period. Do not place the initial concrete if there is more than 3 inches of water in the bottom of the hole.

B. Wet Construction Method. Use the wet construction method at sites where a dry excavation cannot be maintained for placement of the shaft concrete. The wet method consists of using water or slurry to contain seepage and groundwater movement and placing concrete using a tremie or concrete pump. Additionally, use this method to maintain stability of the hole perimeter while advancing the excavation to its final depth, placing the reinforcing cage, and placing the shaft concrete. This method also consists of de-sanding and cleaning the slurry. For drilled shafts that are not socketed into the bedrock and during drilling operations, maintain a water or slurry fluid elevation inside the shaft excavation higher than the static water table. Unless demonstrated to the Engineer's satisfaction that the surface casing is not required, provide temporary surface casings to aid shaft alignment and position and to prevent sloughing of the top of the shaft excavation. Extend surface casings from the ground surface to a point in the shaft excavation where sloughing of the surrounding soil does not occur.

C. Temporary Casing Construction Method. Use the temporary casing construction method when the stability of the excavated hole and/or the effects of groundwater must be controlled. Remove temporary casings while the concrete remains workable. As the casing is being withdrawn, maintain a 5-foot minimum head of fresh concrete in the casing so that all the fluid trapped behind the casing is displaced upward without contaminating the shaft concrete. As necessary, increase the required minimum concrete head to counteract groundwater head inside the casing. Extract casing at a slow, uniform rate with the pull in line with the shaft axis. Rotate, tap, push down, or vibrate the casing when necessary to extract it. Rotate the casing as little as possible to avoid deforming the reinforcing steel cage.

D. Permanent Casing Construction Method. The permanent casing construction method generally consists of driving or drilling a casing to a specified depth before excavation begins. If full penetration of the casing to the specified depth cannot be attained, the Contractor may either excavate material within the embedded portion of the casing or excavate a pilot hole ahead of the casing until the casing reaches the desired penetration. Make the pilot hole no larger than one-half the diameter of the shaft and center the hole in the shaft. Do not over ream to the outside diameter of the casing unless specifically shown on the plans.

Ensure that the casing is continuous between the elevations shown on the plans. Unless otherwise shown on the plans, do not use temporary casing instead of or in addition to the permanent casing.

After installing the casing and excavating the shaft, place the reinforcing steel, then place the shaft concrete. After filling the permanent casing with concrete, pressure grout voids between the shaft excavation and the casing with cement grout. Submit the method of pressure grouting the voids to the Engineer for approval. Pressure grouting is required to ensure contact (bearing) between the casing and any surrounding soil layer that is used for lateral support.

524.05 Friction Type Drilled Shafts. Friction type drilled shafts are defined as drilled shafts that do not bear on bedrock and obtain their ability to support load from a combination of end bearing on the soil and adhesion between soil and concrete along the length of the shaft.

For friction type drilled shafts, dry construction method may be used for cohesive soils only. If using a casing for the construction of a friction type drilled shaft, remove the casing completely or partially as shown on the plans. If enough water is entering the hole through the sides and bottom of the hole such that the supporting soils are being eroded, maintain a positive head of fluid in the excavation hole to ensure that water is not continuously flowing into the hole.

If the Engineer determines that the hole sidewall has softened due to excavation methods, swelled due to delays in concreting, or degraded because of slurry cake buildup, over ream the sidewall to sound material. If the concrete is not placed the same day that the excavation is completed, protect the excavation with a temporary casing, and redrill the hole at least 6 inches larger in diameter, clean the excavation, and perform slurry test before concreting.

524.06 Casings. Use smooth, watertight, steel casings of sufficient strength to withstand handling and driving stresses and the concrete and surrounding earth pressures. Provide an outside diameter of the steel casing equal to or greater than the plan diameter of the shaft. If the plan diameter of the bedrock socket is same as the drilled shaft above the bedrock and a steel casing is used, provide a diameter of the bedrock socket as shown on the plans. Ensure that the diameter of the casing is large enough to allow the excavation of the bedrock socket.

Where drilled shafts are located in open water areas, extend the casing a minimum of 12 inches above the water to protect the shaft concrete from water action during placement and curing of the concrete. Cut off the casing at the plan top of drilled shaft elevation after the concrete has cured. If practical, install the casing in a manner that produces a positive seal at the bottom of the casing to prevent piping of water or entry of other material into the shaft excavation.

If it becomes necessary to remove a casing and substitute a longer or larger diameter casing through caving soils, stabilize the excavation with slurry or backfill before installing the new casing. The Contractor may use other methods accepted by the Engineer to control the stability of the excavation and to protect the integrity of the foundation soils.

524.07 Slurry. Slurry used in the drilling process shall be a mineral or polymer slurry. The mineral slurry shall have both a mineral grain size that remains in suspension and sufficient viscosity and gel characteristics to transport excavated material to a suitable screening system. Ensure that the percentage and specific gravity of the material used to make the suspension is sufficient to maintain the stability of the excavation and to allow proper concrete placement. Maintain the level of the slurry at a height sufficient to prevent caving of the hole.

Thoroughly premix the mineral slurry with clean fresh water and allow adequate time for hydration before introduction into the shaft excavation. Agitate, circulate, and adjust the properties of the slurry to prevent the slurry from "setting up" in the shaft excavation.

Perform control tests using suitable apparatus on the mineral slurry to determine density, viscosity, and pH. Conform to the acceptable range of values for these physical properties as shown in Table 524.07-1.

TABLE 524.07-1 MINERAL SLURRY SPECIFICATIONS
RANGE OF VALUES AT 68 °F

Property	Test Method	Time of Slurry Introduction	Time of Concreting in Hole
Density lb/ft^3	Density Balance	64.3 to 69.1	64.3 to 75.0
Viscosity s/qt	Marsh Cone	28 to 45	28 to 45
pH	pH Paper or meter	8 to 11	8 to 11

If de-sanding is required, do not allow the sand content to exceed 4 percent by volume at any point in the shaft excavation as determined by the American Petroleum Institute sand content test.

Determine density, viscosity, and pH values before and during the shaft excavation to establish a consistent working pattern.

Before placing shaft concrete, use an approved slurry-sampling tool to take slurry samples from the bottom and at mid-height of the shaft. Eliminate heavily contaminated slurry that has accumulated at the bottom of the shaft. Ensure that the mineral slurry conforms to the requirements specified immediately before shaft concrete placement.

Only use polymer slurry after demonstrating to the Engineer that the stability of the hole perimeter can be maintained while advancing the excavation to its final depth by excavating a trial hole of the same diameter and depth as that of the production shafts. Use the same polymer slurry in the trial hole as proposed for the production shafts. If using different sizes of the shafts at the project, use the same size trial hole as that of the largest diameter shaft, except the depth of the trial hole need not be more than 40 feet. Only one trial hole per project is required. Do not use the trial hole excavation for a production shaft. After completing the trial hole excavation, fill the hole with sand. The acceptance of the polymer slurry does not relieve the Contractor of responsibility to maintain the stability of the excavation. Polymer slurry shall conform to the manufacturer's requirements.

524.08 Excavation Inspection. Provide equipment for checking the dimensions and alignment of each shaft excavation. Determine the dimensions and alignment. Measure the final shaft depth after final inspection.

Immediately before placing concrete, ensure that the bottom of the completed drilled shaft excavation is as clean as practical. Remove drilling spoils that adhere to the vertical sides of the bedrock socket.

524.09 Reinforcing Steel for Drilled Shafts. Place the reinforcing steel cage as a unit immediately after inspection of the excavation and before placing concrete. If not placing the concrete immediately after installing the cage, the Contractor may have to remove the cage before placing the concrete to verify the integrity of the excavated area and to ensure loose material is removed from the bottom of the hole.

Tie and support the reinforcing steel so it remains within the required tolerances. Securely tie spacers at quarter points around the cage perimeter and space at intervals not to exceed 5 feet along the length of the cage. If the size of the longitudinal reinforcing steel equals or exceeds 1-inch in diameter, the Contractor may increase the distance between the spacing devices to a maximum of 10 feet. Use spacers of adequate dimensions to ensure a minimum annular space between outside of cage and side of hole or casing of 3 inches for shaft diameters up to 4 feet and 6 inches for shaft diameters larger than 4 feet. The Contractor may use round plastic spacers.

Maintain the top of the reinforcing steel cage no more than 6 inches above and no more than 3 inches the required position. If the reinforcing steel cage is not maintained within tolerances, make acceptable corrections and do not construct additional shafts until the method of reinforcing steel cage support has been approved.

When approved by the Engineer, the Contractor need not provide the reinforcing steel for the extended length of the drilled shaft if it is determined in the field that the Contractor must drill the shaft deeper than the estimated length.

524.10 Concrete for Drilled Shafts. For all drilled shafts, use Class COC 4 or COC 5 concrete for Mass Concrete (drilled shaft diameter over 7 ft) according to Item 511 except as modified and supplemented as follows. The required slump is 6 ± 1 inch. Achieve the additional slump over 4 inches by using chemical admixtures conforming to 705.12, Type F or G. The maximum water-cement ratio shall not exceed 0.44. If placing concrete under water, add 10 percent more cement to the concrete mix. If placing concrete using a tremie, further increase the slump to 8 ± 1 inch, by using chemical admixtures.

For wet method construction, place concrete in one continuous operation from bottom to top of the shaft. After the concrete has reached the top of the drilled shaft, continue pumping and remove all contaminated concrete until acceptable quality concrete is evident at the top of the shaft. Do not vibrate concrete with a vibrator. Carefully remove the casing so that the reinforcing steel cage is not deformed by the force of the downward flowing concrete.

Do not place concrete in any drilled shaft excavation without acceptance from the Engineer. Inspect the drilled shaft excavation immediately before placing the concrete. Provide a light powerful enough to thoroughly inspect the reinforcing steel cage, the sides, and the bottom of the drilled shaft. The inspection for the wet construction method consists of only probing and measuring.

If the elevation of the top of the shaft is below ground at the time of concrete placement, use a casing to prevent caving of materials into fresh concrete.

524.11 Free Fall Concrete Placement. The Contractor may place the concrete in a dry drilled shaft excavation using the free fall method provided the concrete falls to its final position through air without striking the sides of the hole, the reinforcing steel cage, or any other obstruction. Use a centering drop chute, at least 3 feet long with the free fall method. Unless shown on the plans, there is no limit to the height of free fall. If the concrete placement causes the shaft excavation to cave or slough or if the concrete strikes the rebar cage or sidewall, reduce the height of free fall or the rate of concrete flow into the excavation, or both.

If the Engineer determines that dewatering is not practical or placement by free fall method cannot be accomplished, place the concrete using a tremie or a concrete pump.

524.12 Tremie. The Contractor may use a gravity tremie to place concrete placement instead of a concrete pump in either wet or dry holes. For uncased wet holes, maintain the drilled shaft excavation full of slurry or water to such a depth that water does not flow into the shaft excavation at any time. To place concrete, use tremies consisting of a tube of sufficient length, weight, and diameter to discharge concrete at the shaft base elevation. If the tremie contains aluminum parts, do not allow these parts to contact the concrete. Use tremies with an inside diameter of at least 10 inches. Ensure that the inside and outside surfaces of the tremie are clean and smooth to allow both flow of concrete and unimpeded withdrawal during concreting. Use tremies with a wall thickness adequate to prevent crimping or sharp bends that restrict concrete placement.

For concrete placement, use water-tight tremies. Do not begin underwater placement until the tremie is placed to the shaft bottom elevation. Use valves, bottom plates, or plugs so concrete discharge can begin within one tremie diameter of the base. Either remove plugs from the excavation or use plugs of an Engineer approved material that does not cause a defect in the shaft if not removed. Construct the discharge end of the tremie to allow the free radial flow of concrete during placement operations. Immerse the tremie discharge end at least 10 feet in concrete at all times after starting the flow of concrete.

If the tremie line orifice is removed from the fluid concrete column during the concrete pour, and discharges concrete above the rising concrete level, consider the drilled shaft defective.

524.13 Pumped Concrete. Pump concrete into either wet or dry holes. For uncased wet holes, maintain the drilled shaft excavation full of slurry or water to such a depth that water does not flow into the shaft excavation at any time. Use concrete pump pipe at least 4 inches in diameter and constructed with watertight joints. Arrange the concrete pump equipment so no vibrations result that might damage fresh concrete. Arrange pipes carrying concrete from the pump to the shaft with a minimum number of bends. Anchor the pipe used to convey the concrete to the bottom of the drilled shaft excavation to the steel casing or another suitable stationary object to prevent the pipe from undulating during the initial placement of the concrete. Do not begin placing concrete until the pump line orifice is at the shaft base elevation.

Do not use aluminum pipe as a conveyance for the concrete. Pump an adequate quantity of grout, mortar, or concrete without coarse aggregate through the equipment ahead of the specification concrete to provide lubrication to the pumping system. Do not place the concrete used for lubrication in the shaft. The lubrication process will not be repeated as long as the pumping operations are continuous. Operate the pump so a continuous stream of concrete without air pockets is produced. To prevent the contamination of the concrete placed initially at the bottom of the

shaft, seal the outlet end of the pumping pipe with a diaphragm or plug that is flushed out when the hydrostatic pressure from the column of concrete exceeds that of the water in the shaft. Control the initial rate of concrete placement so not to lift or displace the cage of reinforcing steel. Use a watertight conveying system, and leave the outlet end well below the top of the freshly placed concrete. The preferred concrete placement procedure is to maintain the outlet end of the pumping system at approximately 10 feet below the top of the fresh concrete. When the concrete reaches the top of the drilled shaft column, remove all laitance.

If the concrete pump line orifice is removed from the fluid concrete column during the concrete pour, and discharges concrete above the rising concrete level, the drilled shaft shall be considered defective.

524.14 Construction Tolerances. For shafts supporting single columns, position the drilled shaft within 3 inches of the plan location in the horizontal plane at the plan elevation for the top of the shaft. For shafts supporting footings, position the center within 6 inches of the plan location. Do not allow the vertical alignment of the shaft to vary from the required alignment by more than 1/4 inch per foot of depth. Construct the supported elements at the plan location. Perform all corrections required to construct the supported elements.

524.15 Inspection Records. Provide all necessary equipment and labor needed to obtain measurements for completing the Inspection Records. Obtain measurements before placing concrete.

524.16 Method of Measurement. The City will measure Drilled Shafts by the number of feet, measured along the axis of the drilled shaft from the required bottom elevation of the shaft to the proposed top plan elevation. The City will not measure the length of reinforcing steel projecting from the drilled shaft into the pier column or the footing supported on Drilled Shafts as shown on the plans. If the drilled shaft extends into the bedrock, The City will divide the total length of each drilled shaft into two segments. The length of the lower segment is the length of the bedrock socket, and the length of the upper segment is the length of the drilled shaft above the bedrock socket.

If a steel casing extending down to bedrock is used, the City will measure the bedrock socket from the bottom of the casing to the bottom of the drilled bedrock excavation. If the Engineer is assured that a portion of the metal casing is embedded in solid bedrock, and upon the Engineer's concurrence, the City may include the embedded distance as a part of the bedrock socket.

524.17 Basis of Payment. Payment is full compensation for performing required excavation; furnishing and placing steel casings; furnishing and placing reinforcing steel and concrete by free fall, pumping, or tremie method; removing casings; casings left in place; supplying equipment and performing slurry testing; supplying and disposing of slurry; and disposing excess excavated material.

The City will not pay for the cost of performing slurry tests before concreting.

The City will not make separate payment for the trial holes.

The City will not pay for corrections required to construct the supported elements.

The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
524	Foot	Drilled Shafts, ___" Diameter, above Bedrock
524	Foot	Drilled Shafts, ___" Diameter, into Bedrock
524	Foot	Drilled Shafts, ___" Diameter

ITEM 526 APPROACH SLABS

526.01 Description
526.02 Materials
526.03 Forming and Placing Reinforcing Steel
526.04 Placing and Sampling Concrete
526.05 Finishing and Curing
526.06 Side Curbs
526.07 Method of Measurement
526.08 Basis of Payment

526.01 Description. This work consists of constructing reinforced portland cement concrete approach slabs for bridges on the completed and accepted subgrade or subbase.

526.02 Materials. Furnish materials conforming to:

Concrete, Class COC 2* 499
Epoxy coated reinforcing steel 509.02, 709.00
Preformed joint filler..... 705.03
Joint sealer..... 705.04 or 705.11

* Use the same class of concrete used in the bridges superstructure that the approach slab is attached to unless otherwise shown in the plans. If the superstructure concrete class for the bridge is not identified in the plans, use Class COC 2.

526.03 Forming and Placing Reinforcing Steel. Furnish true and straight steel or wooden side forms. Securely brace and hold forms to the line and grade shown on the plans. Do not allow forms to vary more than 1/8 inch from a 10-foot straightedge. Do not remove forms for a minimum of 36 hours. Clean and oil forms after each use.

Furnish reinforcing steel and place it in the position shown on the standard drawing and firmly secure the steel during placing and setting of the concrete. Tie reinforcing bars at all intersections, except tie reinforcing bars at alternate intersections where bar spacing is less than 1 foot in any direction.

526.04 Placing and Sampling Concrete. Immediately before placing concrete according to 511.07, thoroughly moisten the subgrade or subbase with water in the amount and manner directed by the Engineer. The Engineer will make at least four test cylinders for each 50 cubic yards of concrete.

526.05 Finishing and Curing. Mechanically screed, at a vibration frequency of 1500 to 5000 pulses per minute, the concrete surface to the proper elevation in one complete pass with a minimum of hand finishing. If the approach slab is to serve as a base for an asphalt concrete wearing course, texture the approach slab according to Item 305. If the approach slab is to serve as a wearing surface, test the surface according to 451.13, and diamond groove the surface according to 511.17. Cure approach slabs according to 511.14.A.

Open approach slabs to traffic according to Table 511.14-1.

526.06 Side Curbs. If concrete curb extends across the approach slab, construct side curbs of the dimensions required, and place the concrete curb at the same time as the approach slab. Finish the curb according to Item 609.

526.07 Method of Measurement. The City will measure Reinforced Concrete Approach Slabs by the number of square yards complete in place.

526.08 Basis of Payment. The City will pay for accepted quantities at the contract price as follows which includes all concrete, curbs, reinforcing steel, dowels, joints and other materials:

Item	Unit	Description
526	Square Yard	Reinforced Concrete Approach Slabs

600 INCIDENTALS

ITEM 601 SLOPE AND CHANNEL PROTECTION

601.01 Description
601.02 Materials
601.03 General Construction
601.04 Riprap
601.05 Grouted Riprap or Rock
601.06 Crushed Aggregate Slope Protection
601.07 Concrete Slope Protection
601.08 Dumped Rock Fill
601.09 Rock Channel Protection
601.10 Not Used
601.11 Paved Gutter
601.12 Tied Concrete Block Mat
601.13 Articulating Concrete Block Revetment System
601.14 Method of Measurement
601.15 Basis of Payment

601.01 Description. This work consists of the excavation for and the construction of gutters, riprap, concrete, grouted items, tied concrete block mats, articulating concrete block revetment systems, crushed aggregate, or rock items for protecting slopes and channels.

Use removed or excavated materials in the Work when the material conforms to the specifications; if not, then recycle or dispose of the material according to 105.16 and 105.19.

601.02 Materials. Furnish materials conforming to:

Curing	451 or 705.07 Type 1
Concrete, Class COC 6	499, 511
Water for grout	499.02
Reinforcing steel.	509.02
Cement for grout	701
Fine Aggregate for Mortar or Grout.	703.03
Rock and Aggregate Materials	703.19
Brick and blocks	704
Preformed expansion joint	705.03
Joint sealer	705.04
Geotextile Fabric, Type B	712.09
Tied Concrete Block Mat	712.12
Articulating Concrete Block Revetment System	712.13

Provide steel Geotextile Fabric securing pins with washers for securing Geotextile Fabric. Use a steel washer having an outside diameter not less than 1 1/2 inches. Use securing pins at least 18 inches long and at least 3/16 inch in diameter that are pointed at one end and fabricated with a head to retain the steel washer.

Ensure tied concrete block mats and articulating concrete block revetment systems are held together by galvanized steel wire, HDPE mesh, or stainless steel wire.

601.03 General Construction. Cure gutters, concrete slope protection, and grouted riprap according to Item 451, except apply all the membrane cures at the rate of not less than 1 gallon per 200 square feet of surface.

Mix and place all concrete according to Item 511. Finish to produce a sandy texture.

601.04 Riprap. Construct riprap according to one of the following four alternatives unless specifically itemized in the Contract. The Contractor may elect to use a different alternative at each location on the project.

A. Type A - Provide Flat Stones or Broken Concrete. Ensure that individual pieces are roughly rectangular in cross-section with a minimum volume of 1/3 cubic foot and a minimum thickness of 3 inches. Place individual pieces by hand in courses and so that the pieces overlap the joints in the course below. Place riprap with the flat surfaces roughly perpendicular to the slope and in contact with the courses immediately below and above. Fill spaces between larger pieces with spalls that are rammed into place to present an even and tight surface, pleasing in appearance and varying not more than 3 inches from that shown on the plans. When required by the plans, fill riprap with grout. Compact the backing as riprap construction progresses. Ensure that the thickness of the riprap, measured perpendicular to the slope, is not flatter than 9 inches and averages not flatter than 12 inches.

B. Type B - Provide Articulating Concrete Block Revetment System. Ensure articulating concrete block revetment conforms to 712.13.

C. Type C - Construct Concrete Riprap Using Cloth or Burlap Bags. After soaking the bags with water, fill them with approximately 2/3 cubic foot of concrete and place the bags by hand to the limits on the plans. Provide bags with approximate dimensions of 6 × 12 × 16 inches.

Stack the bags on the slope to ensure a minimum of 1/3 cubic yard of concrete for each square yard of riprap in place as measured along the slope.

Tie the open end of each bag and fold the tie under the bag. Place each tie or fold so that it overlaps the joint in the lower layer. After placing, pierce each bag in the lower layer to allow some concrete to flow out and bond with the top overlying layer.

Stretchers are bags placed with the long length parallel to the streambed flow. Headers are bags placed with the long length perpendicular to the streambed flow. A layer runs horizontally at approximately the same elevation perpendicular to the protected slope grade.

If the slope is 1.5:1 or steeper, make the bottom layer with two bags laid as stretchers. Place the next overlying layer as a header. Place the rest of the overlying upslope layers as stretchers.

If the slope is flatter than 1.5:1, make the bottom layer with two bags as stretchers. Place all remaining layers as headers.

Push or drive No. 4 reinforcing bars approximately 18 inches long and spaced approximately 12 inches apart through the top three layers. When required by the plans, fill voids with grout.

D. Type D - Construct a 6-inch Reinforced Concrete Slab. Reinforce the slab approximately midway between the top and bottom of the slab with steel bars or fabricated reinforcement equivalent to No. 3 round bars, spaced at 24-inch centers in two directions, or wire fabric according to the Standard Drawings for pavement reinforcing. The Contractor may use formed construction joints. Extend reinforcement through all formed construction joints. Include cutoff walls as shown on the plans in the unit price bid for reinforced concrete slab.

601.05 Grouted Riprap or Rock. When specified, grout in place riprap cloth bags, riprap burlap bags, flat stones, precast blocks, broken concrete, rock, or tied concrete block mats. Make the grout by mixing one part portland cement, three parts sand, and enough water to allow the grout to flow into the joints and cracks.

Prepare the grout in a mixing machine of an approved design and equipped with an accurate graduated regulating device for controlling the amount of water in each batch. Accurately measure and proportion the quantities for each batch, and ensure that the quantities are exactly sufficient for one or more sacks of cement.

Immediately before applying grout, thoroughly wet all surfaces. Place the grout, filling all the joints or voids. Do not add water to the grout after it has been placed.

601.06 Crushed Aggregate Slope Protection. Furnish material conforming to 703.19. Place the material on the Geotextile Fabric so that the surface is flush with the embankment slopes. Use a thickness of 12 inches unless a different thickness is specified. Extend the aggregate from the face of the abutments down to the toe of the slope or to normal water elevation, and a minimum of 3 feet beyond the outer edges of the superstructures or as shown on the plans.

601.07 Concrete Slope Protection. Construct a concrete slab, 6 inches thick, extending over the embankment area under a bridge from the face of the abutment down to the toe of the slope and extending a minimum of 3 feet beyond the outer edges of the superstructure or as shown on the plans. Thicken the bottom 3 feet of the concrete slab from 6 to 18 inches to provide resistance to sliding.

Where pier columns extend through the slab, place 1-inch preformed expansion joint material around the columns and for the full thickness of the slab.

Divide the surface into an equally spaced block grid pattern at approximately 4 to 5-foot intervals. Make the block grid pattern with one direction horizontally at a constant elevation or as directed by the Engineer, and the other direction parallel to the superstructure centerline, skewed, or as directed by the Engineer. Saw or form the block grid pattern to make joints at a depth of not less than one-fourth the thickness of the slab and approximately 1/8 inch wide.

601.08 Dumped Rock Fill. Furnish material conforming to 703.19. Dump larger pieces at the outer face and smaller pieces in the inner surface of the protected area. Ensure a reasonably smooth and continuous surface conforming to the slope lines shown on the plans. Avoid concentration of fines and small pieces at any location in the completed dumped rock fill material. When required by the plans fill all voids with grout.

601.09 Rock Channel Protection. Furnish material conforming to 703.19. When specified with a filter, provide a filter consisting of Geotextile Fabric or a 6-inch bed of aggregate conforming to 703.19. When placing rock, exercise reasonable care to ensure that the finished surface of the protected channel conforms to the channel cross-sections shown on the plans.

If Geotextile Fabric is used, prepare the surface to receive the fabric to a relatively smooth surface, free of obstruction and debris. With the long dimension parallel to the flow direction, loosely place the fabric without wrinkles and creases. Where joints are necessary, provide a 12-inch minimum overlap, with the upstream strip overlapping the downstream strip. Place securing pins with washers at a minimum distance apart of 2 feet along the joints and at a minimum distance apart of 5 feet everywhere else. When required by the plans fill all voids with grout.

601.10 Not Used.

601.11 Paved Gutter. Construct paved gutter by one of the following methods:

A. Brick. Place bricks with their long dimension perpendicular to the surface of the gutter.

B. Concrete. Mix concrete according to 499.03 for Class COC 6, and place according to Item 499 and 511.12. Construct concrete gutters to the dimensions and shape as shown on the plans or the Standard Drawings.

C. Stone and Broken Concrete. If individual pieces of stone or broken concrete are not of sufficient thickness to meet the requirements of the plans when laid in a single course with their flat surfaces parallel to the surface of the ditch, set the pieces with the flat surface roughly perpendicular to the surfaces of the ditch. Fill with spalls rammed into place.

When the gutter constructed under this Item is bonded or semi-bonded to as existing concrete base, pavement or other rigid structure, match the type and location of joints in the gutter with those in the adjoining pavement.

When gutter is independent of other construction, form impressed joints in the gutter by impressing a device or bar shaped to the section of the gutter into the newly deposited concrete before initial setting. Remove the device or bar as soon as the concrete is in such condition to preclude distortion or injury to the concrete. The groove thus formed shall be 3/8 inch wide at the surface, 1/4 inch wide at the bottom and a depth equal to 1/3 the depth of the concrete. Edge the joints to a radius not greater than 1/4 inch. After the joint is formed, protect it from dirt or foreign matter until the filler is placed. Fill the impressed joints with joint sealer in such a manner that the material will be confined to the joint and in no way mar the surface.

Compact the subgrade for all paved gutters to not less than 90 percent maximum dry density, as defined in 203.07, for a minimum depth of 6 inches below the surface of the subgrade of the paved gutter. Include the cost of compacting the subgrade in the unit price bid for the paved gutter.

601.12 Tied Concrete Block Mat. When specified, use Tied Concrete Block Mat Type ___ conforming to 712.12 as shown on the plans. Place directly on the Geotextile Fabric. Install per the manufacturer's recommendation. Furnish products according to the City's Qualified Products List (QPL).

Tied Concrete Block Mats may be used instead of Rock Channel Protection, Dumped Rock, or Riprap with the approval of the Engineer.

601.13 Articulating Concrete Block Revetment System. When specified, use Articulating Concrete Block Revetment System Type ___ conforming to 712.13 as shown on the plans. Install per the manufacturer's recommendation. Furnish products according to the City's Qualified Products List (QPL).

601.14 Method of Measurement. The City will measure Riprap, Articulating Concrete Block Revetment System, Crushed Aggregate Slope Protection, Concrete Slope Protection, and Tied Concrete Block Mats by the square yard of the finished surface completed and accepted in place, with or without grout.

The City will measure Dumped Rock Fill and Rock Channel Protection (with or without filter), by the cubic yard, completed and accepted in place according to the dimensions shown on the plans, excluding rock filter, with or without grout. The City may determine quantities by volume in the vehicle or by a job conversion weight of acceptable material delivered.

The City will measure Paved Gutter by the foot completed and accepted in place.

601.15 Basis of Payment. The City will specify with grout in the pay item description when required. When the pay item calls out Tied Concrete Block Mat or Articulating Concrete Block Revetment System, include Geotextile Fabric material and installation in the price.

The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
601	Square Yard	Riprap
601	Square Yard	Crushed Aggregate Slope Protection
601	Square Yard	Concrete Slope Protection
601	Square Yard	Tied Concrete Block Mat, Type ___
601	Square Yard	Articulating Concrete Block Revetment System, Type___
601	Cubic Yard	Dumped Rock Fill, Type ___
601	Cubic Yard	Rock Channel Protection, Type ___ with Filter
601	Cubic Yard	Rock Channel Protection, Type ___ without Filter
601	Cubic Yard	Rock Channel Protection, Type ___ with Aggregate Filter
601	Foot	Paved Gutter

ITEM 602 MASONRY

602.01 Description
602.02 Materials
602.03 Construction Requirements
602.04 Method of Measurement
602.05 Basis of Payment

602.01 Description. This work consists of constructing headwalls, pipe cradles, collars, and other brick and masonry units of the types and sizes specified.

Use removed or excavated materials in the Work when the material conforms to the specifications; if not, then recycle or dispose of the material according to 105.16 and 105.19.

602.02 Materials. Furnish materials conforming to:

Backfill..... 203

Concrete, Class COC1.....499 and 511
Water for grout and mortar..... 499.02
Reinforcing steel 509.02
Cement for mortar..... 701.01 through 701.07
Fine Aggregate for Mortar or Grout 703.03
Granular base ..... Granular material, Type B, 703.16.C
Brick and masonry units.....704.01, 704.02, 704.03
Nonshrink mortar 705.22
Lime for mortar. 712.04.A

602.03 Construction Requirements. Construct the designated items as shown on the plans.

A. Excavate to dimensions that provide ample room for construction. Remove obstructions as necessary to perform this work.

Protect the sides of all excavations from caving by providing suitable sheeting, shoring, and bracing. Use excavation methods that do not disturb the original material below the bottom of footers or below the additional 6 inches (required for precast structures.

If the material found at the bottom of the headwall or below the additional 6 inches required for precast structures is not suitable for a foundation, excavate to further depth to provide a suitable foundation. Backfill the void left by the additional excavation with granular base. The City will pay for this additional work according to 109.05.

Backfilling shall follow completion of the work as closely as the construction will allow. Backfill with granular base or soil. Place backfill in 6-inch loose lifts.

B. Compaction requirements are according to Item 203 except for the following:

Perform four passes per lift with additional passes as required until 95 percent compaction. Use compaction equipment with a minimum total weight of, or minimum centrifugal force of, 1 ton. Supply the manufacturer's specifications for this equipment to verify these requirements.

C. Cast-in-place structures are headwalls, wingwalls, pipe cradles, collars, and other units. Construct cast-in-place structures according to the corresponding Standard Drawing using methods specified in Items 499, 511, and 509.

D. Precast structures are half height headwalls for conduits up to a maximum of 78 inches. Precast half-height headwalls for elliptical and pipe arch conduits may be constructed from templates of the actual conduit being supplied, up to a maximum 78 inch (round equivalent) to the project to ensure the opening is OD plus one inch. Submit Working Drawings to the Engineer for approval, on a project by project basis, of precast half-height headwalls for elliptical and pipe arch conduit. Allow 4 weeks for review and approval of Working Drawings. Failure to furnish the Working Drawings will result in rejection of the precast structure. The drawings will include the following:

1. All reinforcing steel will be epoxy coated.
2. Attachment detail for metal or plastic conduit.
3. Non-corrosive lifting devices.
4. Maximum opening is conduit outside diameter plus 1 inch for each conduit material type.
5. All openings to be filled with nonshrink mortar including all lifting device voids.
6. Fill the void between the precast half height headwall and the conduit by using nonshrink mortar.
7. Apply marking, either stamped or painted, to the headwall to ensure each headwall size is matched to the proper conduit size and material type.

E. Pre-cast structures for wingwalls and headwalls for use with 706.05, 706.051, 706.052, and 706.053. Do not use precast footings. The Contractor may provide precast wingwalls or headwalls in lieu of cast-in-place walls using the following criteria:

1. All reinforcing steel shall be epoxy coated.
2. Wall anchorage dowels shall be epoxy coated as per 709.00 or galvanized as per 709.16.
3. Galvanize all connection hardware per 711.02.
4. Install dowels per Item 510 using non-shrink, non-metallic 705.20 epoxy grout.
5. Provide the entrained air requirements as per the applicable concrete specification.
6. Provide Non-corrosive lifting devices.
7. Fill all openings including all lifting hook voids with non-shrink mortar per 705.22.
8. Provide shop drawings detailing precast concrete structural elements and calculations according to the *AASHTO LRFD Bridge Design Specifications.*
9. Have competent individuals prepare and check the shop drawings. Provide a cover sheet containing the preparer(s) and checker(s): First Name, Last Name, Initials and Shop Drawing Content Responsibility. Preparer(s) and checker(s) shall initial each sheet for their content responsibility. The preparer(s) and checker(s) shall not be the same individual. Have an Ohio Registered Engineer review, approve, sign, seal and date the shop drawing cover sheet or submittal letter according to ORC 4733 and OAC 4733-35 confirming that the shop drawings meet the intent of the contract.

10. Submit the shop drawings and calculations to the Engineer at least 7 days before construction begins. City acceptance is not required.

11. The Contractor's written acceptance letter shall document acceptance of the shop drawings including confirmation of field verification, as required, and descriptions of issues resolved between the Contractor, the fabricator, or the City.

12. By accepting these shop drawings, the Contractor represents to the City that all dimensions and elevations of existing conditions shown on the plans have been field measured and verified, and that these shop drawings comply with all the materials requirements, construction requirements, contract requirements, and performance criteria. The Contractor further represents that these drawings have been coordinated and verified with the details of the work to be performed by other fabricators and entities on the project. The City will not make any allowance for additional cost or delays to the Contractor for incorrect fabrication as a result of failure to coordinate or perform this acceptance.

13. If the City requests changes on these shop drawings, or the Contractor makes changes in addition to those expressly requested, ensure that the shop drawings are accepted as above with suitable revision marks to identify the changes.

14. Shop Drawing General Requirements:

a. Provide a separate shop drawing for each culvert location.

b. Provide on 11" x 17" sheets in pdf (portable document format).

c. Show:

i. All dimensions

ii. Inlet and outlet

iii. North arrow

iv. Roadway centerline stationing

v. All construction phases

vi. Precast piece labels

vii. Holes for conduits, framed with diagonal reinforcing on both faces

viii. Reinforcing Lap lengths

ix. Material strengths

x. Weep holes locations

xi. Lifting device locations

d. Label:

i. Project Number

ii. Stream Name as show on plans

iii. Structure File Number or Culvert File Number as given on the plans

iv. Fabrication facility where units are to be cast

F. Masonry units structures are headwalls, pipe cradles, collars, and other units. Thoroughly wet masonry units before laying the mortar. Lay masonry units with full mortar joints. Take adequate precautions to prevent the mortar from freezing. Do not set masonry units having a temperature of 40 °F or less with mortar until heated. When required, heat to ensure that a temperature of 50 to 80 °F is obtained throughout the entire masonry units. Cure the exposed surfaces of the masonry units by covering with wet burlap for 48 hours or by applying curing membrane according to Item 511. Construct the masonry units structures according to the corresponding Standard Drawing. Use one of the following mortars:

1. One part Portland cement to two parts sand by volume. The Contractor may add lime in an amount not to exceed 10 percent of the cement by weight.

2. One part masonry cement to two parts sand by volume.

602.04 Method of Measurement. The City will measure Brick Masonry, Block Masonry, and Concrete Masonry by the number of cubic yards calculated from dimensions shown on the plans.

602.05 Basis of Payment. When a precast structure is used, payment is based on the number of cubic yards required for the cast in place item and is considered full compensation for construction of the precast structure.

The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
602	Cubic Yard	Brick Masonry
602	Cubic Yard	Block Masonry
602	Cubic Yard	Concrete Masonry

ITEM 603 PIPE CULVERTS AND DRAINS

603.01 Description
603.02 Materials
603.03 Definitions
603.04 Material Provisions
603.05 Excavation
603.06 Bedding
603.07 Laying Conduit
603.08 Joining Conduit
603.09 Exterior Coatings and Membrane Waterproofing
603.10 Backfilling
603.11 Placement and Compaction Requirements
603.12 Clearing Site and Restoring Damaged Surfaces
603.13 Field Paving of New or Existing Pipe
603.14 Method of Measurement
603.15 Basis of Payment

603.01 Description. This work consists of constructing or reconstructing long span structures, pipe culverts, and drains (referred to below as Type A, Type D, Type E, and Type F conduit).

Use removed or excavated materials in the Work when the material conforms to the specifications; if not, then recycle or dispose of the material according to 105.16 and 105.19.

603.02 Materials. Furnish materials conforming to:

Soil and granular embankment 203.02.R
Structural backfill, Types 1 and 2 ..... 703.11
Embankment 203.02.R
Concrete for collars and encasement,
  Class COC 6 ..... 499 and 511
Concrete for field paving using aggregate
  No. 7, 8, or 78, Class COC 6 ..... 499 and 511
Reinforcing steel (collars and encasement) 509.02
Mortar 602
Non-shrink mortar 705.22
Bituminous pipe joint filler 706.10
Resilient and flexible gasket joints for:
  Concrete culvert 706.11
  Vitrified clay, B & S 706.12
Preformed butyl rubber joint filler 706.14
4×4 - W1.4 × W1.4 galvanized
  welded wire fabric for field paving 709.08
Type 2 membrane waterproofing 711.25
Type 3 membrane waterproofing 711.29
Fabric wrap, Type 712.09
Joint wrap ..... ASTM C 877
Buried Liner Waterproofing Membrane 711.22

Furnish pipe of the size and kind specified in the Proposal and conforming to applicable subsections of Item 706 and 707. The metric equivalent pipe size may vary with material type for the same English size pipe. The difference in sizes shall not be construed as an exclusion of a material type. The kinds of pipe allowed for each of the designated types of conduit are as follows:

Type A Conduits - Culverts:

Non-reinforced concrete pipe, Class 3 ..... 706.01
Reinforced concrete pipe 706.02
Reinforced concrete pipe, epoxy coated 706.03
Reinforced concrete elliptical pipe 706.04
Precast reinforced concrete box sections 706.05
Precast reinforced concrete 3-sided flat
  topped culverts 706.051
Precast reinforced concrete
  arch sections 706.052
Vitrified clay pipe
  (extra strength only) 706.08

Type B Conduits - Not Used

Type C Conduits - Not Used

Type D Conduits - Drive pipes and bikeways:

Non-reinforced concrete pipe, Class 3 .....706.01
Reinforced concrete pipe.....706.02
Reinforced concrete elliptical pipe.....706.04
Vitrified clay pipe
(extra strength only).....706.08
Corrugated steel conduits..... 707.01 or 707.02
Structural plate corrugated
steel structures 707.03
Corrugated aluminum alloy pipe..... 707.21 or 707.22
Aluminum alloy structural
plate conduits.....707.23
Corrugated polyethylene
smooth lined pipe.....720.12
Polyvinyl chloride corrugated
smooth interior pipe.....720.10
Polyvinyl chloride solid wall pipe.....720.08

Type E Conduits - Miscellaneous small drain connections and headers:

Non-reinforced concrete pipe.....706.01
Reinforced concrete pipe.....706.02
Reinforced concrete elliptical pipe.....706.04
Concrete drain tile, extra quality 706.07
Vitrified clay pipe.....706.08
Clay drain title, extra quality.....706.09
Corrugated steel conduit..... 707.01 or 707.02
Corrugated aluminum alloy pipe..... 707.21 or 707.22
Corrugated polyethylene
smooth lined pipe.....720.12
Polyvinyl chloride plastic pipe
(non-perforated).....720.07
Polyvinyl chloride corrugated
smooth interior pipe.....720.10
Polyvinyl chloride solid wall pipe.....720.08

Type F Conduits - Conduits on steep slopes; underdrain outlets:

Corrugated steel conduits
(steep slope conduit), Type C ..... 707.05 or 707.07
Corrugated aluminum alloy pipe
(steep slope conduit)..... 707.21 or 707.22
Corrugated polyethylene
smooth lined pipe (underdrain outlets) 720.12
Polyvinyl chloride plastic pipe
(non-perforated underdrain outlets) 720.07
Polyvinyl chloride corrugated
smooth interior pipe (underdrain outlets).....720.10
Polyvinyl chloride solid wall pipe
(underdrain outlets).....720.08

603.03 Definitions. For the purposes of this specification, the following definitions are used:

A. Long span structure includes all of the following material kinds: 706.05, 706.051, and 706.052.

B. Plastic pipe includes all of the following material kinds: 720.01, 720.07, 720.08, 720.10, and 720.12.

C. Corrugated metal pipe includes all of the following material kinds: 707.01, 707.02, 707.03, 707.04, 707.05, 707.07, 707.13, 707.14, 707.21, 707.22, and 707.23.

D. Not used.

E. Rigid Pipe includes all of the following material kinds: 706.01, 706.02, 706.03, 706.04, 706.08, and 706.09.

F. Conduit includes long span structures, pipe, culverts, drains, or any other item specified herein.

G. Backfill is soil, granular embankment, or structural backfill placed above the bedding to the elevation as described.

H. A cut situation is an existing field situation when the top of the conduit is below the existing ground where an embankment may be constructed.

I. A fill situation is an existing field situation when the top of the conduit is above the existing ground where an embankment is to be constructed.

J. A fill situation meets the requirements of a cut if the fill is constructed to at least 2 feet above the top of the conduit before placing the conduit.

K. The conduit rise is the vertical distance from outside wall to outside wall or outside corrugation measured at the middle of the conduit.

L. The conduit span is the horizontal distance from outside wall to outside wall or outside corrugation measured at the widest point of the conduit.

M. The conduit spring line is equal to the rise divided by two.

N. Trench width is the horizontal distance between the vertical walls of the trench measured in feet.

603.04 Material Provisions.

The Engineer will allow any of the following alternate material provisions:

A. The Contractor may use Type 1 or 2 structural backfill if granular or soil embankment is required or allowed.

B. Supply pipe of the required size or one size larger.

C. If 707.05 or 707.07 conduit is specifically itemized or specified in the Proposal, the Contractor may provide conduit conforming to 707.04 and having a bituminous paved invert. Provide the same corrugation profile and sheet thickness listed in the Proposal.

D. The Contractor may furnish higher strength concrete or plastic pipe of the same type where lower strength pipe is specified.

E. The Contractor may furnish a thicker metal pipe of the same corrugation profile and type where a lesser thickness is permitted or specified.

F. If 706.02 reinforced concrete pipe is specifically shown on the plans as "special design", the manufacturer shall submit shop drawings and design calculations by a Registered Engineer for review and written approval before manufacture. Submit a minimum of seven copies of the shop drawings and allow a minimum of 4 weeks for approval. Include the following in the shop drawings:

1. All structural design and loading information.
2. All material specifications.
3. All dimensions.

Design reinforced concrete pipe based on *AASHTO LRFD Bridge Design Specifications*, Section 12.

G. If a 706.05 structure is specifically itemized or specified in the Contract, the Contractor may submit to the City for approval a request to supply a 706.051 structure placed on precast slab bottom, or a 706.052 structure placed on precast slab bottom, that is hydraulically equivalent and meets all cover requirements. The manufacturer shall submit shop drawings and hydraulic calculations by a Registered Engineer for review and approval before manufacture. The bottom slab may be cast-in-place with approval from the City; however, there will be no increase in time permitted.

H. If 706.051 or 706.052 is specifically itemized or specified in the Contract, on footers, the Contractor may substitute each one for the other upon structure approval for hydraulics and cover. The manufacturer shall submit shop drawings and hydraulic calculations by a Registered Engineer for review and approval before manufacture. If 706.051 or 706.052 is specifically itemized or specified in the Contract, on pedestal walls, the Contractor may substitute each one for the other upon structure approval for hydraulics, cover and pedestal wall design. 706.051 or 706.052 require different pedestal wall designs.

I. All 706.051 or 706.052 shop drawings require a Registered Engineer signature for design and check. The manufacturer shall submit shop drawings and hydraulic calculations to the City for review and approval before manufacture.

J. For metal pipe 54 inch diameter or larger and pipe-arch, ensure the manufacturer provides match marked ends and a layout drawing.

603.05 Excavation. Measure trench width at the span of the conduit. Center the trench excavation about the centerline of the conduit.

Use Method A for a cut situation, and use Method B for a fill situation.

A. **Method A.** Excavate the trench for the conduit. Provide vertical trench walls.

If long span culvert is used, provide a minimum trench width of the span plus 2 feet on each side.

If rigid pipe is used, provide a minimum trench width of the span times 1.33.

If plastic or corrugated metal pipe is used, provide a minimum trench width of the span times 1.25 plus 1 foot.

If plastic pipe is used and the ID is 8 inch or less, furnish a minimum trench width of the OD.

Increase these minimums to a width that allows the jointing of the conduit, and the placement and compaction of the backfill.

B. Method B. Construct the embankment to a height at least equal to half of the rise and to a width on each side of the conduit two times the span of the conduit before excavating for the conduit. Excavate the trench in the constructed embankment to a width conforming to Method A above.

Furnish a firm foundation for the conduit bed for its full length. The Engineer will require the removal of unsuitable material below the conduit bedding or below the bottom of the conduit if bedding is not required for the width of the trench. Replace the unsuitable material with structural backfill. Remove rock or shale in the conduit foundation for at least 6 inches below the bottom of the bedding. Replace the rock or shale with structural backfill. Unless in the contract documents, the City will pay for this work according to 109.05.

If the Engineer changes the flow line by more than one foot, the City will pay according to 109.05.

The Contractor may jack or tunnel the pipe with the written permission of the Director.

603.06 Bedding. Type 1 bedding consists of structural backfill extending at least 6 inches below the bottom of the conduit for the full width of the trench. Compact the bedding according to 603.11.

Use Type 1 bedding for 706.05, or 706.051 and 706.052 on slab bottoms, or corrugated invert plates.

Type 2 bedding consists of structural backfill extending at least 3 inches for all Item 706 rigid pipe conduits and 6 inches for all other conduits below the bottom of the conduit for the full width of the trench. Extend the bedding up around the pipe for a depth of not less than 30 percent of the rise of the conduit. Shape the bedding to fit the conduit with recesses shaped to receive the bell of bell-and-spigot pipe. Leave the bedding below the middle one-third of the pipe span uncompacted. Compact the remaining bedding according to 603.11.

Use Type 2 bedding for Types A and D conduits except for long span structures and for conduits that require Type 3 bedding.

Type 3 bedding consists of a natural foundation with recesses shaped to receive the bell of bell-and-spigot pipe. Scarify and loosen the middle one-third of the pipe span.

Use Type 3 bedding for Type D conduits of the following materials: 706.01, 706.02, or 706.03.

Type 4 bedding consists of a natural foundation shaped to fit the conduit with recesses shaped to receive the bell of bell-and-spigot pipe.

Use Type 4 bedding for Types E and F conduits.

603.07 Laying Conduit. Lay the conduit in the center of the trench starting at the outlet end with the bell or groove-end laid upgrade. Ensure that the conduit is in contact with the bedding throughout its full length such that line and grade is maintained. Lay metal conduits according to one of the following methods:

A. If the seam is longitudinally either riveted or welded, place the seam or weld at the spring line.

B. If the metal pipe is fabricated helically (having a continuous seam running around the outside of the pipe), arrange the corrugations so the helix angle or twist is rotating downstream in the direction of the flow to increase hydraulic performance.

Maintain flows at all times until the new facilities are completed and in service. Maintain the flows through existing facilities to be replaced unless a temporary bypass conduit is used.

Construct the inlet and outlet ends of all conduit runs with pipe ends as normally fabricated by the manufacturer. If field cutting is necessary, locate the cut end at an interior joint within the run and provide a cradle, collar, or band to ensure a stable joint.

Construct a concrete collar on the last joint if field cutting is necessary to meet a structure or headwall.

Erect 707.03 and 707.23 conduits according to 522.03. Where two plate thicknesses are specified, locate the thicker plates at the bottom and corner plates in pipe-arch structures, and the bottom row, if centered, or bottom two rows, if not centered, in round structures.

Set the 706.051 units on the concrete footing shown on the plans. Unless otherwise shown on the plans, provide a 3-inch deep by 14-inch wide keyway in the center of the footing. Place the units in a 1/2-inch bed of mortar. If proper line and grade of the structure cannot be maintained on the bed of mortar, set the units on 5 × 5-inch masonite or steel shims. Fill the entire keyway joint with mortar.

Set the 706.052 units on the concrete footing shown on the plans. Unless otherwise shown on the plans, provide a 3-inch deep by 14-inch wide keyway in the center of the footing. Place the units on 5 × 5-inch masonite or steel shims to provide a minimum 1/2-inch gap between the footing and bottom of the unit's bottom leg. Fill the entire keyway joint with mortar.

If reinforced concrete pipe has elliptical reinforcing, the top and bottom of the pipe are clearly marked on the pipe. Handle and place reinforced concrete pipe with elliptical reinforcement and reinforced concrete horizontal elliptical pipe with single cage reinforcement with the reinforcement markings along a vertical plane as marked on the pipe. Handle and place reinforced concrete pipe with auxiliary supports (S-stirrups) with the centerline of the auxiliary support system (S-stirrups) in a vertical plane as marked on the pipe.

For 706.05, 706.051, or 706.052 structures fill the lifting devices with mortar. Cover the exterior of the lifting devices with joint-wrap material if outside the limits of the membrane waterproofing. Use joint-wrap with a minimum width of 9 inches. Use only lifting devices that do not require a hole through the structure.

For all Item 707 conduit, use only lifting devices that do not require a hole through the structure.

Immediately after placing conduit, construct the end treatments at both the outlet and inlet ends. These end treatments include headwalls, concrete riprap, rock channel protection, sod or other erosion control items.

603.08 Joining Conduit. Join the conduit sections so that the ends are fully entered and the inner surfaces are flush and even. Furnish sealed, banded, or bolted joints for Types A, D, and F conduits. Provide open joints for Type E conduits wrapped with 4-inch wide tarred paper or tarred burlap with pack soil placed around this material to hold it in place during backfilling.

The Engineer may allow joint materials other than those listed below, provided the Contractor demonstrates the proposed material makes durable sealed joints.

Furnish joints that do not allow infiltration of backfill material into the conduit or use a fabric wrap on the outside of the conduit.

Install conduit so that match marks align and in accordance with the layout drawings supplied by the manufacturer.

A. Joints.

1. Metal Pipe.

If using corrugated metal pipe, provide coupling bands conforming to 707.01 or 707.02. These bands will have the same coating as the pipe being joined and use gasketed coupling bands or fabric wrap the coupling bands when using structural backfill Type 2 for the bedding or backfill. A maximum difference between adjacent pipe sections of 1/2 inch will be allowed before coupling bands are placed. Securely strut the end of each pipe section for pipe diameters 54 inches or greater that have a wall thickness of less than 0.109 inch. Install the ties or strapping in the first or second valley of the annular corrugations on each end of each piece of pipe. Install two struts per end such that they are perpendicular to one another and cross at their midpoints. Strut by using wire ties or other approved methods. Remove the strutting after securing the coupling bands.

2. Rigid Pipe.

a. For 706.01, 706.02, or 706.04, 706.05, or 706.08 that require sealed joints, use any of the following methods:

i. Apply 706.10 to the pipe in sufficient quantity to completely fill the joint once the pipe is placed in its final position at a gap of 1 inch or less. After placing the pipe in its final position, point and trowel the 706.10 to form a smooth transition on the inside and a complete seal on the outside.

ii. Apply 706.14 to the pipe in sufficient quantity to seal the joint but not necessarily fill the joint once the pipe is placed in its final position at a gap of 1 inch or less. Immediately before installing 706.14, clean the joint free of all debris then prime both sides of the joint with an asphalt based primer according to the 706.14 manufacturer's recommendations.

iii. Provide 706.11 or 706.12 as specified.

b. For 706.03 conduit, use fibrated coal tar joint compound applied according to the manufacturer's recommendations.

B. Filling Joints. After placing 706.05, 706.051, or 706.052 in their final position with a maximum joint gap of 1 inch, clean the joint gap or joint of all debris and perform the following:

1. For 706.05 joints, fill the top exterior joint gap and the bottom and side interior joint gap with mortar. Next, for any exterior joint not covered by membrane waterproofing, cover the exterior joint with a 9-inch wide strip of joint wrap. Center the joint wrap on the joint. Use a continuous length of joint wrap sufficient to extend from the bottom of the vertical face on one side to the bottom vertical face on the other side.

2. For 706.051, fill the top keyway joint with 705.22. The side or leg joints shall also be filled with 705.22 for the key way type joint or filled per 706.05 for a tongue and grove type joint. Clean the joint of all debris immediately before installing the joint filling material. Prepare, place, and cure the 705.22 according to the manufacturer's recommendations. Wet all surfaces of the keyway joint, but do not allow excess water in the joint. Next, for any exterior joint not covered by membrane waterproofing, cover the exterior joint with a 12-inch wide strip of joint wrap. Center the joint wrap on the joint. Use a continuous length of joint wrap sufficient to extend from the bottom of the vertical face on one side to the bottom vertical face on the other side.

3. For 706.052, install a 7/8 × 1 3/8-inch 706.14 joint filler along the outside joint chamfer. Use a continuous length of joint filler sufficient to extend from the bottom of the vertical face on one side to the bottom vertical face on the other side. Before installing the joint filler, prime the joint chamfer with a primer according to manufacturer's recommendations. Next, cover the exterior joint with a 9-inch wide strip of Type 3 membrane waterproofing centered on the joint, and then apply all waterproofing as shown on the plans. For any exterior joint not covered by membrane waterproofing, cover the exterior joint with a 12-inch wide strip of joint wrap. Use a continuous length of joint wrap sufficient to extend from the bottom of the vertical face on one side of the structure to the bottom vertical face on the other side.

C. Sealing Concrete Surfaces. For 706.05, 706.051, or 706.052, apply an approved epoxy sealer per the plans to all top surfaces not covered by membrane waterproofing. Extend the sealer 1 foot below the backfill on all sides of the culvert sections including the joint.

The Engineer and Contractor will visually inspect all conduit and joints before any backfill is placed. Rejoin, re-lay, or replace all conduit out of joint tolerance, alignment, settled, or damaged.

603.09 Exterior Coatings and Membrane Waterproofing. Apply waterproofing to 706.05, 706.051, 706.052, 707.03, and 707.23 conduits with less than eight feet of cover by one of the following methods.

A. Coat the exterior of the conduit above the limits of the bedding and within the limits of backfill. Ensure that all plate seams and bolts are thoroughly sealed. The coating material and application shall conform to AASHTO M 243. Allow asphalt mastic material to dry 48 hours and tar base material to dry 28 hours before placing the conduit backfill. Rib stiffeners do not need to be coated.

B. Construct Buried Liner Waterproofing Membrane protection in the fill per the manufacturer's recommendations. The Buried Liner Waterproofing Membrane protection will be a seamless continuous sheet placed over the conduit and extend at least 10 feet outside of the paved shoulder and for the width of the trench.

For 707.03 and 707.23 conduits, coat the exterior of the conduit above the limits of the bedding and within the limits of backfill. Ensure that all plate seams and bolts are thoroughly sealed. The coating material and application shall conform to AASHTO M 243. Allow asphalt mastic material to dry 48 hours and tar base material to dry 28 hours before placing the conduit backfill. Rib stiffeners do not need to be coated.

Include the cost for the waterproofing and application in the unit price bid for the Item 603 Conduit.

603.10 Backfilling. Place backfill to the limits described and according to the compaction requirements. Place the backfill in the trench and embankment outside the trench uniformly on both sides of the conduit for all conduit installations.

A. General. The Contractor may operate small compaction equipment with less than a total weight of 1 ton over the conduit to compact the backfill. Do not use hoe packs on top of the conduit until 2 feet of backfill is compacted on top of the conduit. The Contractor may operate compaction equipment with less than a total weight of 8 tons, but more than 1 ton, over the conduit after placing and compacting 2 feet of backfill. Do not operate equipment with a total weight of 8 tons or more, until placing and compacting a cover of 4 feet over the top of the conduit. The above restrictions apply when working within one span on each side of the conduit, or 6 feet, whichever is less. As shown on the plans, encase conduits with the specified thickness of Class COC 6 concrete.

B. Long Span.

1. For long span structures in cut, place and compact structural backfill over the top of the section to a minimum depth 4 feet or to the subgrade elevation, whichever is less, and for a width of 2 feet on each side of the section. Use soil, granular embankment, or structural backfill to construct the adjacent embankment and for the remaining depth to the subgrade. Construct the adjacent material according to Item 203.

2. For long span structures in fill, place and compact structural backfill over the top of the section to a minimum depth of 2 feet or to the subgrade elevation, whichever is less, and for a width of 2 feet on each side of the section. Use soil, granular embankment, or structural backfill to construct the adjacent embankment and for the remaining depth to the subgrade. Construct the adjacent material according to Item 203.

C. Type A. Backfill Type A conduits except for long span structures as follows:

1. In a cut situation, place and compact structural backfill above the bedding for the full depth of the trench. Within the trench and more than 4 feet above the top of the conduit, if the trench can accommodate compaction equipment, the Contractor may construct Item 203 Embankment. For plastic pipe with an ID 8 inch or less, place and compact structural backfill above the bedding for the full depth of the trench.

2. In a fill situation, place and compact structural backfill above the bedding for the full depth of the trench specified in 603.05.B. Above these limits, uniformly place the lesser of one pipe span or 4 feet of structural backfill on each side of the conduit and to a depth of 2 feet above the top of the conduit. Construct the embankment outside the limits of the backfill. For plastic pipe with an ID 8 inch or less, place and compact structural backfill above the bedding for the full depth of the trench.

D. Type D. Backfill D conduits as follows:

1. In a cut situation, for plastic pipe, place and compact structural backfill above the bedding and to 12 inches over the top of the pipe. All other conduit material types place and compact backfill. For plastic pipe with an ID 8 inch or less, place and compact structural backfill above the bedding for the full depth of the trench.

2. In a fill situation, for plastic pipe, place and compact structural backfill above the bedding for the full depth of the trench specified in 603.05.B. Above these limits, uniformly place the lesser of one pipe span or 4 feet of structural backfill on each side of the conduit and vertically to the top of the conduit. Then place for a depth of 12 inches structural backfill over the top of the pipe equal to the trench width centered on the pipe center line. Construct the embankment outside the limits of the backfill. For all other conduit material types, place and compact backfill. For plastic pipe with an ID 8 inch or less, place and compact structural backfill above the bedding for the full depth of the trench.

E. Type E. Place and compact backfill above the bedding to a height equal to two-thirds of the conduit rise, then place and lightly compact backfill for a depth of 12 inches above the pipe. Place no stones larger than 4 inches that will be part of the embankment in contact with the pipe.

F. Type F. Place and compact backfill above the bedding. Backfill Type F conduits for underdrain outlets according to 605.03.C.

603.11 Placement and Compaction Requirements. Place soil, granular embankment, or Structural Backfill Type 1 or 2 in lifts not to exceed 8 inches. The City will perform all compaction testing according to Supplemental Specification 1501. The compaction requirements per material type are as follows:

A. For soil embankment, compact each lift until 96 percent of AASHTO T 99 is achieved.

B. For granular embankment and Structural Backfill, Type 1 or 2, compact each lift of material according to 603.11.E using mechanical devices, hoe packs, jumping jacks, hand devices, vibrating plates, or other equipment that meets the restrictions in 603.10. Provide compaction equipment that compacts the material under the haunch of the pipe. If the compaction equipment cannot fully compact the material under the haunch, supplement the compaction equipment by using shovel slicing, spud bars, or mechanical spud bars to compact the material under the haunch of the pipe. Use shovel slicing and spud bars in conjunction with the compaction operations to compact the material and to manipulate the material under the haunch of the pipe.

C. For Structural Backfill Type 2, compact each lift of material according to 603.11.E using flood compaction or mechanical devices, hoe packs, jumping jacks, hand devices, vibrating plates, or other equipment that meets the restrictions in 603.10. Provide compaction equipment that compacts the material under the haunch of the pipe. If the compaction equipment cannot fully compact the material under the haunch, supplement

the compaction equipment by using shovel slicing, spud bars, or mechanical spud bars to compact the material under the haunch of the pipe. Use shovel slicing and spud bars in conjunction with the compaction operations to compact the material and to manipulate the material under the haunch of the pipe.

D. At the beginning of the work, construct a test section in the conduit trench. The Engineer will use at least 96 percent of the test section maximum dry density for acceptance of the production areas. Use at least the same number of passes or compactive effort used to construct the test section to compact the production areas. Use compaction equipment with a total weight or centrifugal force of at least 1/2 ton. Supply the manufacture's specification for the compaction equipment. Except when using a hoe pack, use at least six passes with the compaction equipment in the production areas.

The Engineer may reduce the minimum passes if the passes are detrimental to compaction.

Construct a new test section if the pipe type, bedding material, backfill material, or trench conditions change.

E. If using trench boxes with Type A conduit, configure the trench box so that the bedding and backfill material is compacted directly against the trench walls.

F. The Engineer may adjust the lift thickness to obtain the required compaction, fill all the voids, achieve the proper seating of the backfill material, and achieve the stability of the backfill material and the pipe. Do not use equipment or methods that compromise the structural integrity of the pipe.

603.12 Clearing Site and Restoring Damaged Surfaces. Immediately after completion of the placing and compacting of the backfill, remove and dispose of all surplus material according to 603.01 and clear the site and restore all required surfaces

603.13 Field Paving of New or Existing Pipe. Field pave the bottom of the conduit with concrete as shown on the plans.

For new pipe installations, do not pave until at least 4 feet of fill is placed on top of the conduit, or the top of subgrade is reached. If the paving is placed before completion of the entire fill, clean any gaps between the conduit and concrete paving, then fill with heated bituminous material conforming to 705.04.

Reinforce the paving with 4 × 4-W1.4 × W1.4 galvanized welded wire fabric (or comparable). Provide a mesh with a width 4 inches less than the finished paving. Securely fasten the mesh to the conduit near each edge and at the center of the mesh at points not more than 4 feet apart along the flow line of the culvert. Repair any damage to the galvanizing or other coating material caused by placement or by tack welding. Use wire brushing and paint with zinc rich paint to make the repairs.

For aluminum structural plate, securely fasten the mesh to the circumferential seam bolts with galvanized tie wire.

Provide a paving that is 3 inches thick measured from the top of the corrugations of the conduit to a height equal to 1/3 of the rise. Provide galvanized reinforcing steel support chairs beneath the mesh where necessary. Give special care to the mesh during concrete placement. After placing the concrete, strike it off with a template to produce the proper radius, and finish with a float to produce a smooth finish. Cure the concrete according to 451.10.

603.14 Method of Measurement. The City will measure conduit by the number of feet, measured from center-to-center of appurtenant small structures or between open ends inclusive of lengths of pipe bends and branches. The City will not deduct for catch basins, inlets, or manholes that are 6 feet or less across, measured in the direction of flow. Where the location of an appurtenance or an open end is changed with the approval of the Engineer to accommodate full conduit sections, the City will measure the length placed. Conduits placed on slopes steeper than 3:1 or with beveled or skewed ends will be measured along the invert.

When the pay item calls for concrete encasement, payment for furnishing and placing the concrete encasement and for any additional excavation required shall be included in the unit bid price for the pertinent conduit. When the pay item calls for a new conduit to be field paved, payment for the field paving, including all work and materials necessary for the item, shall be included in the unit bid price for the pertinent conduit.

The City will measure field paving of existing pipe by the number of feet.

603.15 Basis of Payment. The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
603	Foot	___" Conduit, Type ___
603	Foot	___ × ___ Conduit, Type ___
603	Foot	___" Conduit Reconstructed, Type ___
603	Foot	Type ___ Precast Reinforced Concrete Flat Topped Three-Sided Culvert, ___' Span × ___' Rise
603	Foot	Type ___Precast Reinforced Concrete Arch Sections, ___' Span× ___' Rise
603	Foot	___' Rise × ___' Span Conduit, Type A Corrugated Steel Box Culvert, ___' Minimum Cover, ___' Maximum Cover
603	Foot	___' Rise × ___' Span Conduit, Type ___ Corrugated Aluminum Box Culvert, ___' Minimum Cover, ___' Maximum Cover

603	Foot	___" Conduit, Type ___, with Field Paving of Pipe
603	Foot	___" Conduit, Type ___, Field Paving of Existing Pipe
603	Foot	Conduit, Type F for underdrain outlets

ITEM 604 MANHOLES, CATCH BASINS, INLETS, INSPECTION WELLS, JUNCTION CHAMBERS, PRECAST REINFORCED CONCRETE OUTLETS, OR MONUMENTS

604.01 Description
604.02 Materials
604.03 Construction Methods, General
604.04 Excavation and Backfill
604.05 Brick and Block Masonry
604.06 Precast Concrete Modular Construction
604.07 Concrete (Cast-In-Place)
604.08 Method of Measurement
604.09 Basis of Payment

604.01 Description. This work consists of constructing or reconstructing manholes, catch basins, inlets, inspection wells, junction chambers, precast reinforced concrete outlets, or monuments of the type and sizes specified; or adjusting existing castings to grade, as specified.

Use removed or excavated materials in the Work when the material conforms to the specifications; if not, then recycle or dispose of the material according to 105.16 and 105.19.

604.02 Materials. Furnish materials conforming to:

Structure concrete, Class COC 6.	499, 511
Brick and masonry units	704
Precast reinforced concrete manhole, catch basin, and inlet sections	706.13
Precast reinforced concrete outlet	706.15
Preformed expansion joint fillers	705.03
Epoxy coated reinforcing steel	509.02, 709.00
Cast frames, grates, and covers	711.12, 711.13, or 711.14
Welded frames and grates	513.17, 711.01
Steps	711.13, 711.30, or 711.31
Structural backfill	703.11
Resilient and flexible gasket joints	706.11
Curing materials	705.05, 705.07
Mortar	602
Nonshrink Mortar…	705.22

When precast structures such as manholes, inlets, headwalls, endwalls, catch basins or any similar structures are proposed to be incorporated into the work, submit the following:

(a) Manufacturer's name.
(b) Detail design plans
(c) Material specifications

The City will base approval on complete inspection of manufacturer's facility and production, materials to be used, and final product. All products delivered to the job site will also be subjected to functional tests and must be marked with a "COC" stamp.

Deliver castings to the project unpainted.

604.03 Construction Methods, General. Construct the specified structures according to the plans. Place inlets, catch basins, inspection wells, junction chambers, monuments, or precast outlets at the locations and elevations shown in the plans according to the Standard Drawings or as directed by the Engineer. Place manhole castings at the elevation and station with offset to the center of the casting or as directed by the Engineer. Place the manhole base at the elevation and station with offset to agree with the pipe station, offset and pipe invert elevation according to the Standard Drawings or as directed by the Engineer. Use flat slab top manholes as shown on the Standard Drawings. Do not remove the flat slab top manhole lifting devices.

If the Engineer changes the structure elevation by more than 1 foot, the City will pay according to 109.05.

Thoroughly mortar with a flush mortar joint the underdrain outlet pipe to the precast reinforced concrete outlet. Furnish and place lateral sewer connections including drops and leads except pipe included in Item 603.

Locate or cut conduits as shown on the standard drawings so they do not protrude inside the structure walls.

Take adequate precautions to prevent structure concrete or mortar cement from freezing. Preheat the brick, concrete block, or precast concrete structure throughout the entire mass to a temperature between 50 to 80 °F before placing mortar if the ambient temperature is 40 °F or less.

Set iron frames, tops, and covers of the type shown on the plans in a mortar bed with a flush mortar joint.

Prevent earth or debris resulting from construction operations from entering the manholes, catch basins, junction chamber, inlets, and precast reinforced concrete outlets. Remove any debris.

Sanitary manholes located in impervious areas shall require a concrete collar and sanitary manholes located in pervious areas shall require a flexible chimney seal.

A. Reconstruction to Grade.

1. Carefully remove and clean the existing castings.
2. Remove the existing walls of manholes down to the spring line or below as necessary.

Remove existing walls of catch basins and inlets below the window openings, grates, or any points of wall failure.

Using the salvaged casting, reconstruct the structure to the new grade, conforming as nearly as practicable to the existing dimension and type of construction.

B. Adjustment to Grade.

1. Carefully remove and clean the existing frame, adjust the height of supporting walls, and reset the existing frame in a bed of concrete mortar or structure concrete to the new grade.
2. Carefully remove the existing cover or grate and install a casting or an adjusting device approved by the Engineer to the new grade and install per the manufacturer's recommendations.
3. Secure extension ring in place by applying mastic, conforming to 706.10, to the entire contact surface between the casting and extension.

C. Allowable Tolerance.

The maximum allowable tolerance is minus ¼-inch for all structure lids and grates below the finished pavement surface. There is no allowable tolerance for structure lids and grates above the finished pavement surface.

604.04 Excavation and Backfill. Excavate to dimensions that provide ample room for construction.

The Engineer will require the removal of unsuitable material below the structure bedding. Replace unsuitable material with 703.11. When the Engineer requires the removal and replacement of unsuitable material below the bedding for precast structures and below the structure for cast-in-place structures, the City will provide compensation according to 109.05.

Ensure that the backfilling follows the completion of the work as closely as the type of construction will permit. Do not disturb the structure while backfilling. Backfill structures located within the pavement area with structural backfill to the subgrade according to Item 912. Backfill structures outside of the pavement area according to Item 911.

604.05 Brick and Block Masonry. Lay the first course of bricks or blocks on a full bed of mortar. Thoroughly wet brick and concrete block masonry units before laying in the mortar, and lay the brick and masonry units with a flush mortar joint. Joint thickness shall not exceed ½" in thickness. Brick and block shall match the width of the precast structure. Courses shall be placed in a running bond breaking the joints by ½ the length of a brick or block.

Take adequate precautions to prevent concrete and mortar from freezing. Do not set brick and masonry units having a temperature of 40 °F or less with mortar until heated. When required, heat to ensure that a temperature of 50 to 80 °F is obtained throughout the entire mass of the material.

Apply a plaster coat of mortar to the interior and exterior surfaces of brick, concrete brick or block masonry. The plaster coat shall be with the same mortar used in laying the bricks or blocks and not less than ½ inches in thickness. Before applying the plaster coat adequately wet the block to ensure bonding to the plaster coat.

Cure the exposed surfaces of all brick and block masonry by covering with wet burlap for 48 hours or by applying curing membrane according to Item 511.

604.06 Precast Concrete Modular Construction. Furnish precast bases on a compacted structural backfill bed having a minimum thickness of 3 inches. Ensure that the structural backfill bed is level and uniformly support the entire area of the base.

Catch basins and inlets manufactured with knock-out panels will only be permitted where the construction drawings show a pipe entering the structure that will replace the panel.

All joints between modules shall be as follows:

Sanitary manholes shall conform to the requirements of ASTM C443 as it pertains to the use of a confined gasket.

Storm sewer applications shall be in conformance with ASTM C443, 706.10 or 706.11.

Pipe entrances to the precast modular sections for sanitary sewers 8 inches to 48 inches in diameter shall be a flexible watertight joint in accordance with 706.16.

Pipe entrances to the precast modular sections for storm sewers shall be in accordance with 706.16, or neatly grouted in place. Grout shall be placed to fill the void on both the exterior of the pipe, prior to backfill and the interior once backfilled. Backfill operations shall commence once the exterior grout has hardened sufficiently.

All lift holes and other openings in the structure shall be thoroughly and neatly grouted with cement mortar or other suitable material approved by the Engineer, after all pipes are placed into the structure.

All sanitary manholes shall be watertight structures.

Cure median inlets with the same materials and methods specified in 622.07.

604.07 Concrete (Cast-In-Place). Place and furnish structure concrete as shown on the plans.

604.08 Method of Measurement. The City will measure Manholes, Inlets, Catch Basins, Monument Assemblies, Reference Monuments, Inspection Wells, Junction Chambers, and Precast Reinforced Concrete Outlets, whether new, reconstructed, or adjusted to grade, by the number of each type of structure complete and accepted.

604.09 Basis of Payment. The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
604	Each	Manholes
604	Each	Inlets
604	Each	Catch Basins
604	Each	Monument Assemblies
604	Each	Reference Monuments
604	Each	Right-of-Way Monuments
604	Each	Inspection Wells
604	Each	Junction Chambers
604	Each	Manhole, Catch Basin or Inlet Reconstructed to Grade
604	Each	Manhole, Catch Basin, Inlet, or Monument Box Adjusted to Grade
604	Each	Precast Reinforced Concrete Outlet

ITEM 605 UNDERDRAINS

605.01 Description
605.02 Materials
605.03 Pipe Underdrains Construction
605.04 Construction Underdrains
605.05 Prefabricated Edge Underdrains
605.06 Underdrain Outlets
605.07 Aggregate Drains
605.08 Method of Measurement
605.09 Basis of Payment

605.01 Description. This work consists of constructing unclassified pipe underdrains, pipe underdrains, or rock cut underdrains with or without a Geotextile Fabric, construction underdrains, prefabricated edge underdrains and aggregate drains.

Use removed or excavated materials in the Work when the material conforms to the specifications; if not, then recycle or dispose of the material according to 105.16 and 105.19.

605.02 Materials.

Concrete, Class COC 6..... 499 and 511
Reinforcing steel 509.02
Geotextile Fabric, Type A 712.09

Backfill unclassified pipe underdrains, pipe underdrains, or rock cut underdrains with or without a Geotextile Fabric, construction underdrains and aggregate drains with granular material consisting of No. 8, 57, 9, or 89 size air-cooled blast furnace slag, limestone, or gravel. Use granular material with a maximum sodium sulfate soundness loss of 15 percent.

Backfill prefabricated edge underdrains with granular material consisting of No. 8 size air-cooled blast furnace slag, limestone, or gravel. Use granular material with a maximum sodium sulfate soundness loss of 15 percent.

For 605.02.A through 605.02.B, use the pipe of the same size and kind listed in the Proposal. If the kind of pipe is not specifically itemized in the Proposal, use types as listed below.

A. Pipe for Item 605 Rock Cut Underdrains

Corrugated polyethylene drainage tubing
(perforated)..... 720.01
Smooth-wall polyvinyl chloride underdrain
Pipe..... 720.07

Polyvinyl chloride corrugated smooth interior pipe
(perforated per 720.01) 720.10
Polyvinyl chloride solid wall pipe
(perforated per 720.01) 720.08

B. Pipe for 605 Unclassified Pipe Underdrains, Pipe Underdrains.

Perforated concrete pipe 706.06
Concrete drain tile, extra quality 706.07
Perforated vitrified clay pipe 706.08
Clay drain tile, extra quality 706.09
Corrugated steel underdrains, Type III 707.01
Corrugated polyethylene
drainage tubing, (perforated) 720.01
Polyvinyl chloride plastic pipe 720.07
Corrugated aluminum alloy pipe and
underdrains, Type III 707.21

C. Pipe for Item 605 Construction Underdrains

6 inch Corrugated polyethylene drainage
tubing (perforated) 720.01

D. Pipe for Item 605 Prefabricated Edge Underdrains. Use pipe conforming to 712.10.

605.03 Pipe Underdrains Construction. Construct underdrains as follows:

A. Excavation. Excavate trenches to such dimensions allowing ample room for construction. Construct the trench width to at least 14 inches for 6-inch diameter underdrains, and to at least 6 inches for 4-inch diameter underdrains. Excavate the trench walls as vertical as possible, and excavate bell holes to allow proper placing of the underdrain. Remove obstructions encountered while excavating for the underdrains.

Excavate trenches measured vertically as shown in the Standard Drawings unless otherwise specified in the plans. Furnish a depth of 30 inches for construction underdrains unless otherwise specified in the plans. Excavate trenches for unclassified pipe underdrains to the depth specified in the plans.

Excavate trenches to a depth of 6 inches below the rock, shale or coal depth required in 204.05 for Rock Cut underdrains unless otherwise specified in the plans.

If underdrains are to be placed within or beneath an embankment, construct the embankment to the elevation of the top of the subgrade before trenching for the underdrain.

If fabric is specified, line the underdrain trench with Geotextile Fabric. Place the Geotextile Fabric to completely surround the granular material. Overlap the Geotextile Fabric at the top of the trench. Match the overlap to the trench width. At other seams, overlap Geotextile Fabric a minimum of 12 inches.

B. Laying Underdrain. Lay the underdrain true to line and grade with close fitting joints. Place the underdrain in the center of the trench. Use locking bands or smooth sleeve type couplers matching the underdrain material type to join 707.01, 720.01, 720.07, and 707.21. When bell and spigot underdrain is used, lay it with the bell end facing up grade. Set the underdrain on a solid bed shaped to fit the underdrain throughout its entire length. Make all necessary connections with branches, wyes, tees, transitions, and bends that match the underdrain material type. Close the upper ends of underdrains with suitable plugs.

Lay perforated underdrain so that the perforations are in the bottom half of the underdrain.

C. Backfilling. Inspect the underdrains before placing any granular material. Place the granular material for the full width of the trench around the underdrain, and extend it to the bottom of the pavement or base as shown on the plans. If underdrains are placed outside of the pavement or base area, extend the granular material to within 4 inches of the finished grade. Fill the remaining depth of the trench with Item 203 embankment material.

D. Protection. Place the pavement over the underdrain trench within 90 days after placing the trench backfill. If the trench remains open for longer than 90 days, remove and replace backfill contaminated by soil.

605.04 Construction Underdrains. Construct construction underdrains as follows:

A. Excavation. Construct the trench width to at least 10 inches with a minimum of 2 inches on each side of the underdrain. Excavate the bottom of the trench to allow proper placing of the underdrain. Remove obstructions encountered while excavating for the underdrains.

B. Trench Depth and Backfill. Construct the trench depth to that shown on the plans or 30 inches. Backfill the trench with granular material for the full width of the trench and to the full height of the trench.

C. Outlet. Outlet the construction underdrains as possible into the ditch or drainage structures. There is no change in pipe types for the outlet.

D. Removal. Construction underdrains are not to be removed at any time. If the construction practice used requires the construction underdrains to be removed then install replacements as soon as possible.

605.05 Prefabricated Edge Underdrains. Install the prefabricated edge underdrains against the outside wall of a 4-inch trench, and backfill the trench adjacent to the pavement with granular material. Place the granular material in one or more lifts with a vibratory compactor run over the final lift to compact the granular material before placing the asphalt plug. Place the first layer of the granular material simultaneously with the trenching operation to hold the edge underdrains flush against the trench wall.

Splice the prefabricated edge underdrains as required before placing in the trench, using material furnished by the manufacturer and according to the manufacturer's directions. Require the manufacturer to furnish all material required for the splices, and furnish any equipment required for splicing. Construct splices to prevent separation of adjoining sections of the prefabricated edge underdrain panels.

605.06 Underdrain Outlets. Construct pipe outlets concurrently with underdrains. Provide all outlets on the slope with a precast reinforced concrete outlet according to Item 604 and a tied concrete block mat Type 1 grouted according to 601.12.

Construct the underdrains outlets according to Item 603 using outlet fittings. Require the manufacturer to supply outlet fittings that transition between the underdrains and the outlet pipe. Provide smooth-lined or corrugated outlet fittings. Have the underdrains and outlets on fractured slab projects, such as crack and seat, rubblized, or break and seat projects, in place and functional before fracturing the existing pavement.

Mark all underdrain outlets with a wooden lath prior to final seeding. Clean all debris from the outlets after final seeding.

605.07 Aggregate Drains. Construct the aggregate drains after the completion of granular pavement courses.

A. Excavation. Excavate trenches for aggregate drains to a minimum width of 12 inches and to the depth shown on the plans. Slope the bottom of the trench to drain and keep it free from loose particles of soil. Excavate the trench to furnish a clean exposure of the granular pavement courses.

B Placing and Backfilling. Use granular material for the drains. Place the aggregate to a minimum depth of 8 inches above the bottom of the trench. The remaining depth of the trench backfill with suitable embankment material according to Item 203.

605.08 Method of Measurement. The City will measure Unclassified Pipe Underdrains, Pipe Underdrains, Construction Underdrains, Rock Cut Underdrains, and Prefabricated Edge Underdrains by the number of feet completed and accepted in place, measured from end to end of each run.

The City will measure Aggregate Drains by the number of feet completed and accepted in place, measured along the bottom of the trench.

605.09 Basis of Payment. The City will pay for pipe outlets under Item 603 Conduit, Type F.

The City will pay for precast reinforced concrete outlets under Item 604 Precast Reinforced Concrete Outlet.

The City will pay for tied concrete block mats Type 1 grouted under Item 601 Tied Concrete Block Mat.

Rock Cut Underdrains are placed in rock and all required trenching in the rock is included under Rock Cut Underdrain.

The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
605	Foot	____ " Unclassified Pipe Underdrains
605	Foot	6" Construction Underdrains 720.01
605	Foot	____ " Pipe Underdrains
605	Foot	Aggregate Drains
605	Foot	____ " Rock Cut Underdrains
605	Foot	____ " Prefabricated Edge Underdrains

ITEM 606 GUARDRAIL

606.01 Description
606.02 Materials
606.03 Setting Posts
606.04 Erecting Rail Elements
606.05 Guardrail Rebuilt
606.06 Impact Attenuators
606.07 Method of Measurement
606.08 Basis of Payment

606.01 Description. This work consists of constructing or reconstructing guardrail, guardrail posts, bridge terminal assemblies, end terminals, and impact attenuators, including the furnishing, assembling, and erecting of all component parts and materials.

Guardrail shall be deep beam rail Type MGS, 5, 5A, or 8. Appurtenances shall include bridge terminal assemblies, end terminals, and impact attenuators. Construction of the various types of guardrail include the furnishing, assembling, and erecting of all component parts and materials, complete in place, at the location shown on the plans or as directed, and according to the manufacturer's recommendations where applicable.

606.02 Materials. Furnish materials conforming to:

Concrete, Class COC 1, COC 2 or COC 6 .... 499 and 511
Reinforcing steel 509.02
Deep beam rail and hardware 710.06

Pressure treated guardrail posts
and blockouts..... 710.14
Steel guardrail posts 710.15
Guardrail posts 710.16
Galvanizing 711.02

For guardrail, use deep beam rail Type MGS, 5, 5A, or 8.

606.03 Setting Posts. Set or drive posts plumb in a manner that prevents battering or distorting of posts. Trim posts that are set or driven more than 1-inch above grade. Treat trimmed posts with a preservative material specified in 712.06. Backfill post holes with acceptable material, placed in layers, and thoroughly compacted.

606.04 Erecting Rail Elements. Erect standard design (single-faced) guardrail of the type shown on the plans. Erect barrier design (double-faced) guardrail as shown on the plans.

Erect rail elements in a manner resulting in a smooth, continuous installation. Use shop-curved rail on curves with radii from 5 to 70 feet.

Except where otherwise required, such as expansion joint bolts, draw bolts tight. Tighten bolts through expansion joints as tight as possible without preventing the rail elements from sliding past one another longitudinally. Provide bolts long enough to extend at least 1/4 inch beyond the nuts.

Do not use splice bolts that extend more than 1/2 inch beyond the nuts. For double-faced guardrail, provide bolts that extend from 1/4 to 1 inch beyond the nuts.

Fabricate all metal in the shop. Do not perform burning or welding in the field. The Engineer may approve making holes in the field, but only for special details in exceptional cases. The Engineer may approve field punching, cutting, and drilling if the Contractor demonstrates that its methods do not damage the surrounding metal.

Repair galvanized surfaces that have been abraded such that the base metal is exposed, including threaded portions of all fittings and fasteners, and cut ends of bolts as specified by ASTM A 780 except the City will not allow aerosol spray applications of paints containing zinc dust.

Erect guardrail so that the bolts at expansion joints are located at the centers of the slotted holes. Splice the rail elements by lapping in the direction of traffic. Ensure that the plates at each splice make contact throughout the area of the splice.

606.05 Guardrail Rebuilt. As shown on the plans, rebuild existing guardrails. Unless otherwise shown on the plans, rebuild units of the same type and spacing of members as the existing guardrail.

For re-erecting, obtain the rail element from specified salvage sources. Furnish the following new materials: posts, blockouts, bolts, washers, and incidental hardware as necessary to complete the guardrail, except: (1) existing steel posts and blockouts that are not damaged and have a good galvanized coating may be reused, and (2) reuse guardrail splice bolts that are undamaged and were not removed during salvage may be reused.

606.06 Impact Attenuators. Before installing the attenuator, make all corresponding shop drawings from the manufacturer available for the Engineer's inspection. Include installation drawings and instructions with the shop drawings that completely describe the attenuator system.

Grade the top of each foundation at the same elevation as the adjacent travel lane and/or paved shoulder.

Adjust the location of the anchors to avoid pavement joints.

The Contractor shall use City approved proprietary impact attenuator products.

606.07 Method of Measurement. The City will measure Guardrail, new or rebuilt, of the type specified by the number of feet from center-to-center of end posts, excluding anchor assemblies. If, however, end connections are made to masonry or steel structures, the City will measure to the center of the normal post bolt slot. If rail element is used across a bridge, the City will measure to the first post off the bridge.

The City will measure Anchor Assembly of the type specified by the number each assembly furnished and erected complete.

The City will measure Bridge Terminal Assembly of the type specified by the number of each assembly furnished and erected complete.

The City will measure Impact Attenuator of the type specified by the number of each furnished and erected complete.

The City will measure Guardrail Post of the kind specified by the number of each furnished and erected.

606.08 Basis of Payment. The additional costs associated with furnishing and installing extra-length posts instead of standard-length guardrail posts are incidental to Guardrail Post, 8-foot or Guardrail Post, 9-foot.

For the extra costs associated with furnishing and installing extra-length posts in lieu of standard-length guardrail posts, payment for 9-foot guardrail posts is considered full compensation.

The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
606	Foot	Guardrail, Type ___
606	Foot	Guardrail, Barrier Design, Type ___
606	Foot	Guardrail, Rebuilt, Type ___
606	Each	Anchor Assembly, Type ___
606	Each	Anchor Assembly, Barrier Design, Type ___
606	Each	Bridge Terminal Assembly, Type ___

606	Each	Impact Attenuator, Type ___
606	Each	Guardrail Post
606	Each	Guardrail Post, 8-foot
606	Each	Guardrail Post, 9-foot

ITEM 607 FENCE

607.01 Description
607.02 Materials
607.03 Clearing, Grading and Seeding
607.04 Post Assemblies
607.05 Horizontal Deflection
607.06 Line Posts
607.07 Fabric
607.08 Barbed Wire
607.09 Method of Measurement
607.10 Basis of Payment

607.01 Description. This work consists of furnishing and erecting fence and gates of the types designated. Construct fence in a manner that provides a rigid, taut fence closely conforming to the surface of the ground.

Fence is designated by the following types:

A. Type 47 [47-inch] woven wire fence fabric, steel line posts, and one strand of barbed wire.

B. Type 47RA [47-inch] woven wire fence fabric, wood line posts, and no barbed wire.

C. Type CLT [60-inch] chain-link fence fabric with tension wire.

607.02 Materials. Furnish materials conforming to:

Concrete, Class COC 1, COC 2 or COC 6.... 499 and 511
Reinforcing steel 509.02
Barbed wire 710.01
Woven steel wire fence 710.02
Chain-link fence 710.03
Fence posts, braces, and dimension lumber..... 710.11
Steel line posts and ties, Type 47 fence 710.11
Expansion shield anchors, self drilling..... 712.01
Seeding and Mulching..... 659

607.03 Clearing, Grading and Seeding. Perform clearing and grading as necessary to construct the fence to the required alignment, and provide a reasonably smooth ground profile at the fence line. Perform fenceline seeding and mulching according to Item 659 Seeding and Mulching on all areas disturbed by the clearing and grading for the fence within 8 months of the activity. The City will deduct the area paid for under Item 607 Fenceline Seeding and Mulching from Item 659 Seeding and Mulching quantities as described in the plans, if applicable.

607.04 Post Assemblies. Securely brace end, corner, gate, and pull or intermediate anchor posts in position during the curing period of the concrete encasement. The Engineer will not require forms for post encasement.

For Type 47 and Type CLT fence, ensure that the maximum spacing between intermediate anchor post assemblies, or between end post assemblies and intermediate anchor post assemblies, are 660 feet.

607.05 Horizontal Deflection. At points of horizontal deflection, construct the fence as follows:

A. Type 47 Fence. If the fence changes alignment by more than 1 degree but not more than 4 degrees, install either steel line posts encased in concrete or wood posts without encasement at all horizontal deflection points. If the change in alignment is more than 4 degrees and less than 30 degrees, build an intermediate anchor post assembly at the deflection point. If the change in alignment is 30 degrees or more, build a corner post assembly at the deflection point.

B. Type CLT Fence. If the fence changes alignment by more than 1 degree but not more than 4 degrees, install line posts encased in concrete at all horizontal deflection points. If the change in alignment exceeds 5 degrees, provide a post brace and truss rod in each fence panel adjacent to the post located at the angle point. If the change in alignment exceeds 5 degrees, construct the footings for all post located at deflection points as specified for end posts.

607.06 Line Posts. Set line posts according to the following:

A. Type 47 Fence. Space line posts at intervals not to exceed 12 feet. Anchor line posts at the bottom of dips or depressions in the ground surface in concrete. If channels or streams cross the fence line, construct crossings as shown on the plans.

On tangents, place line posts so that the fabric, when installed on the side toward the highway, is 2 feet from the Right-of-Way line. If adjacent to Right-of-Way lines with less than 5740 feet radius (in excess of 1 degree curvature), construct line posts on chords so that the fabric, when installed on the side toward the highway, is not less than 2 feet or more than 8 feet from the Right-of-Way line.

Locate posts at points of horizontal deflection so that the fence fabric will bear against the post.

B. Type CLT Fence. Protect the tops of driven line posts by drive caps or other method to prevent distortion of the exposed end. Space line posts at not more than 10-foot centers, and place them so that, when the wire is fastened on the side toward the highway, it is 1 foot from the Right-of-Way line.

607.07 Fabric. If setting posts in concrete, do not erect the fabric until after 5 days from the time of setting the posts when using regular concrete, or until after 3 days when using concrete with high early strength cement,

Stretch and securely fasten Type 47 fabric to line posts using galvanized ties. At a minimum, use one tie each for the top and bottom horizontal wires and one tie for each alternate horizontal wire below the top horizontal wire.

Fasten chain-link fabric to the line posts using clips or bands spaced approximately 14 inches apart, and to the top rail or top tension wire using bands or tie wires at approximately 24-inch intervals or less. Join successive rolls of fabric by weaving a single picket into the ends of the rolls to form a continuous mesh.

607.08 Barbed Wire. If barbed wire is specified, stretch and fasten it in the same manner as woven wire fabric.

607.09 Method of Measurement. The City will measure Fence, Type ___ by the number of feet, complete in place. The City will measure along the top of the fence from outside to outside of end posts, exclusive of gates and other openings.

The City will count Gate, Type ___ by the number of complete units of the size and type specified.

The City will measure Fenceline Seeding and Mulching by the number of feet of fence. The City will measure along the top of the fence from outside to outside of end posts, exclusive of gates and other openings.

607.10 Basis of Payment. The City will pay for accepted quantities at the contract prices as follows:

Seeding and Mulching shall be paid under Item 607 Seeding and Mulching

Item	Unit	Description
607	Foot	Fence, Type___
607	Each	Gate, Type___
607	Foot	Fenceline Seeding and Mulching

ITEM 608 WALKS, CURB RAMPS, AND STEPS

608.01 Description
608.02 Materials
608.03 Concrete Walks
608.031 Concrete Walks with Buff Wash Finish
608.04 Asphalt Concrete Walks
608.05 Crushed Aggregate Walks
608.06 Concrete Steps
608.07 Curb Ramps
608.08 Method of Measurement
608.09 Basis of Payment

608.01 Description. This work consists of constructing walks, curb ramps, and steps as per plans, specifications and standard drawings.

608.02 Materials. Furnish materials conforming to:

Aggregate Base .....304.01 and 304.02
Asphalt concrete Type 1..... 441
Concrete,
Class COC 1 or COC 6..... 499
Reinforcing steel..... 509.02
Crushed aggregate meeting
grading requirements of..... 703.10
Detectable Warning Devices 712.14
Expansion Joint Material..... 705.03

608.03 Concrete Walks. Construct concrete walks as follows:

A. Excavation. Excavate to the required depth and to a width that allows installation and bracing of forms. Shape and uniformly compact the subgrade to a surface conforming to the plans and the requirements of Item 203 or as directed by the Engineer.

B. Forms. Use either fixed forms or slip-form methods. For fixed-form construction, use wooden or metal forms that extend the full depth of the concrete and that do not spring under the concrete pressure. For slip-form construction, perform the work according to 609.04.C.

C. Placing and Finishing. Finish concrete surface according to Item 451. The Contractor shall not use water or finishing agents to assist in the finishing of the concrete surface. If the contractor is observed using water or finishing agents, then the entire area will be subject to removal and replacement at no additional cost to the City. Immediately before placing concrete, thoroughly moisten the subgrade. Deposit concrete in a single

layer, strike it off with a template, and smooth it with a float to obtain a sandy texture. Do not plaster the concrete. Use a 1/4-inch radius edging tool to edge all outside edges and joints. Divide the surface of the walks into equally spaced rectangular blocks at approximately 5-foot intervals. Saw or form transverse joints to a depth of not less than one-fourth the thickness of the slab and to a width of approximately 1/8 inch. Install 1/2-inch thick expansion joint filler between the walk and any fixed structure that extends the full depth of the walk, and between appurtenances such as manholes or utility poles extending into and through the sidewalk. Install 1-inch thick expansion joint filler between the walk and the back of curb that is on a 250-foot or smaller radius, such as at street intersections. Place transverse expansion joint strips 1/2 inch in thickness and extending the full depth of the walk at intervals of not more than 30 feet.

D. Slope. Construct the surface of the walk with a maximum transverse slope rate of 0.02 and with the low side adjacent to the roadway. The requirements of the City of Columbus ADA Rules and Regulations apply to the construction of sidewalks.

E. Curing. Cure concrete according to Item 451.

608.031 Concrete Walks with Buff Wash Finish. Construct concrete walks with buff wash finish as follows:

A. Excavation and Forms. Excavate and construct forms according to 608.03.A and 608.03.B.

B. Placing and Finishing. After float finishing, trowel surface once concrete is firm enough on which to work. Immediately after final troweling, spray-apply chemical surface retarder to pavement, according to manufacturer's written instructions. After concrete has firmed even more while still being able to be worked, without dislodging aggregate disturb and remove mortar paste by lightly brushing surface in several directions with a stiff, nylon-bristle broom while washing with water. Remove 3-5 mils of paste until small aggregates begin to appear. Fine-spray surface with water and brush. Repeat water flushing and brushing cycle until cement film is removed from aggregate surfaces to depth required and that the appearance of the finish concrete matches that of the approved samples. Surfaces shall have a coarse sandy appearance when completed. Apply evaporation retarder after completing the washing of the surface. Do not let concrete slurry dry to freshly washed finishes or adjacent pavements. If surface paste is to be removed by power-washing, verify that the underlying concrete is firm enough to withstand the spray. Use a cone shaped nozzle and spray curing retardant and paste away to expose a sandy like finish to the concrete.

C. Slope. Construct the surface of the walk in accordance with 608.03.D.

D. Curing. Cure the walk according to 608.03.E. Use Clear Waterborne Membrane-Forming Curing Compound: ASTM C 309, Type 1, Class B. Curing compounds used on exposed concrete pavements shall not exhibit a white or milky film after application. The curing compound shall not be used as the final sealer for the concrete

Seal the concrete using Salt-Guard by Prosoco or equal. Salt-Guard shall be applied twice to all exposed concrete pavement surfaces per manufacturer's recommendations once the concrete is fully cured. Other water based-siloxane sealers applied per manufacturer's recommendations and approval at the discretion of the City.

E. Sample Work. Construct a 5 foot square sample of Buff Wash finished concrete for approval by the Engineer.

Construct as many mock-ups as necessary to achieve an accepted mock-up. Mock-ups which are partially constructed or finished incorrectly will be rejected. Remove rejected mock-ups immediately from the site. Accepted mock-up shall become the project standard for tolerances and appearance. If matching plan location and grades, accepted mock-ups may be incorporated into the finished work.

608.04 Asphalt Concrete Walks. Construct asphalt concrete walks as follows:

A. Excavation and Forms. Excavate and construct forms according to 608.03.A and 608.03.B.

B. Base. Place and thoroughly compact aggregate base in layers not exceeding 4 inches in depth.

C. Asphalt Placement and Compaction. Place asphalt concrete in one or more courses to provide the required depth. Compact using a hand roller or power roller of a type and weight acceptable to the Engineer.

608.05 Crushed Aggregate Walks. Construct crushed aggregate walks as follows:

A. Excavation. Excavate according to 608.03.A.

B. Forms. Construct forms of wood or metal of acceptable rigidity and to the depth of the necessary loose material. Back forms with compacted soil to the height of the completed walk.

C. Aggregate Placement and Compaction. Place aggregate in one or more courses to provide the required depth. Compact using equipment of a type and weight acceptable to the Engineer.

608.06 Concrete Steps. Construct concrete steps as follows:

A. Excavation and Forms. Excavate and construct forms according to 608.03.A and 608.03.B.

B. Placement and Finishing. Place and finish concrete according to Item 511, except finish the treads of steps to produce a sandy texture.

C. Slope. Slope step treads at a rate of 0.0156 and toward the next lower step.

D. Curing. Cure steps according to 608.03.E. Use 705.07, Type 2 (opaque) curing compound.

E. Railing. If specified, install hand railing according to Item 517.

608.07 Curb Ramps. Excavate, form, place, finish, and cure according to 608.03.A, 608.03.B, 608.03.C, and 608.03.E. Finish ramps to a rougher final surface texture than the adjacent walk and with striations transverse to the ramp slope using a coarse broom or other method approved by the Engineer. This work shall consist of constructing curb ramps, including ramps, flares, landings, and sidewalk transitions, in accordance with

lines, grades and dimensions shown on the plans or established by the Engineer. The running slope of a curb ramp should be a minimum of 5% and maximized up to 7.69% wherever possible to promote positive drainage. All work shall comply with the requirements of the City of Columbus ADA Rules and Regulations. This work shall also consist of completing the Curb Ramp Compliance Checklist by the designated ADA compliance officer for each curb ramp installed. Provide Detectable Warnings conforming to 712.14. Place detectable warnings in accordance with Standard Drawing 2319 and manufacturer's installation instructions.

Detectable warning surfaces shall be classified by type of materials and/or application method. The City will allow the following types of Detectable Warnings only:

Type A: Pre-cast, manufactured clay and concrete pavers. Type A is approved only for new construction.

Type D: Surface-mounted, thin tile and thin molded sheet goods. Generally includes tiles or mats (rigid and flexible, with preformed truncated domes), bonded and/or anchored to the surface of existing curb ramps. Type D is only approved for retrofit, or where a grade break in the detectable warning is necessary.

Type E: Pre-manufactured, wet-set products. Generally includes rigid products pressed into freshly formed concrete.

608.08 Method of Measurement. The City will measure Concrete Walk, Asphalt Concrete Walk, and Aggregate Walk by the number of square feet of finished surface, complete in place.

The City will measure Curb Ramps by the number of each completed. The City will measure Detectable Warnings in curb ramps and at grade crossings by the number of square feet completed.

The City will measure Concrete Steps by the number of feet, along the front edge of each tread. Where steps are constructed with integral walls, the City will include the thickness of the integral walls with the tread width measurement.

608.09 Basis of Payment. Payment for walks, curb ramps, detectable warnings, and steps is full compensation for excavation, backfill, concrete cutting/sawing, base course material, reinforcing steel, hand railing, expansion joint materials, finishing**,** and any incidentals required to complete the installation as specified.

Payment for Curb Ramps is made for each individual curb ramp in addition to the area payment for the concrete walk where a curb ramp is constructed. Payment for Curb Ramps includes any additional materials, grading, forming, finishing, curb ramp engineered design, completing the Curb Ramp Compliance Checklist, and any incidentals required to complete the installation of the curb ramp beyond what is covered in the Concrete Walk Item. Detectable warnings will be paid separately.

The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
608	Square Foot	Concrete Walk
608	Square Foot	Asphalt Concrete Walk
608	Square Foot	Aggregate Walk
608	Each	Curb Ramps
608	Square Foot	Detectable Warning Type ___
608	Foot	Concrete Steps
608	Square Foot	Concrete Walk with Buff Wash Finish

ITEM 609 CURBING, CONCRETE MEDIANS, AND TRAFFIC ISLANDS

609.01 Description
609.02 Materials
609.03 Stone Curb
609.04 Cast-in-Place Concrete Curb and Combination Curb and Gutter
609.05 Asphalt Concrete Curb
609.06 Concrete Median and Traffic Island
609.07 Method of Measurement
609.08 Basis of Payment

609.01 Description. This work consists of furnishing and constructing curb, combination curb and gutter, medians, and traffic islands. This work also consists of excavating, backfilling, furnishing and installing joint materials, and disposing of surplus excavation and discarded materials according to Item 203.

609.02 Materials. Furnish materials conforming to:

Concrete, Class C 499
Expansion joint material..... 705.03
Aggregate base 304, 703.04
Preformed filler 705.03
Tie bar steel, epoxy coated
.....709.00, 709.01, 709.03, 709.05
Coated dowel bars 709.13

For 609.03 Stone Curb, furnish the best quality of Berea or Amherst gray sandstone, or sandstone of equal quality.

Furnish asphalt concrete curb conforming to Item 441 Type 1 intermediate course. Conform the asphalt concrete to the composition requirements with the fine aggregate content set at the maximum allowed under this composition. Provided the Contractor meets the composition requirements, the Contractor may add mineral filler conforming to 703.07. Add the mineral filler using a method approved by the Laboratory.

Furnish Granite Curb per the Standard Drawing or to match existing granite curbs, produced in random lengths of not less than 36 inches from granite complying with ASTM C615. Include all labor, materials, equipment and incidentals necessary for construction in the unit cost of Item 609 Granite Curb.

609.03 Curb.

A. Sandstone Curb.

1. Cutting and Dressing. Ensure that 95 percent of all straight curb pieces are at least 5-feet long, with no pieces less than 42 inches. Use curb section a minimum of 30 inches for closure(s). For curves with a radius of 50 feet or greater, use radially jointed straight curb pieces between 36 and 42 inches long. For curves and corners with a radius of less than 50 feet, use pieces a minimum of 36-inches long, and dress, joint, and set pieces to the radii specified. For all curves and corners, use curb sections that are approximately uniform in length.

Dress all curb to a straight edge on top and on the exposed face and ends to a depth of at least 6 inches below the gutter elevation. Dress the ends at right angles to the face for straight curb and radially for curb on curves. Place joints that are free of slack or hollow. Place joints smooth and free of projections after dressing the ends of any curb section that exceed 1/8 inch from the plane of the end of that section. Cut the edge next to the gutter to a 3-inch radius and dress the top to a 1/4-inch bevel rising from the exposed face. Use a pitching tool on the edge at the back to hand dress curb to the specified width.

2. Setting. Set the curb on a thoroughly compacted subgrade and with a 1 in 20 batter from the vertical backward from the gutter. Use a heavy rammer to settle the curb into place. Place and compact a minimum 4-inch wide aggregate backfill behind the curb to within 6 inches of the top. Bring the balance of the backfill to the level of the top of the curb for a distance of 2 feet behind the curb with soil or other acceptable material. Thoroughly tamp the backing in layers not exceeding 6 inches in thickness, loose measurement, with an approved tamper or rammer. Perform as much of the backfilling and tamping as is consistent with alignment of the curb at the time the stone is first set. Set curb on curves in plastic concrete 6-inches thick as shown on the plans. Extend concrete the width of the curb plus 6 inches behind the curb, and bring concrete up behind the curb to within 4 inches of the top.

3. Joints. Set curbs such that below the dressed portions the space between ends of adjacent sections of curbing is not less than 1/8 inch at any point and not more than 4 inches. Cushion the joints between the dressed portions of adjacent sections of curbing with 1/8-inch thick expansion joint material. Trim expansion joint material flush with the curbing on all edges.

If placing sandstone curb after placing pavement, fill remaining joints with dry sand to within 2 inches of the surface of the pavement, and fill to the pavement surface with asphalt concrete. Take care in filling this joint so that no asphalt concrete comes in contact with the exposed surface of the curb.

4. Reusing Existing as New Curb. If specifically allowed by the plans, and to the extent available, use acceptable stone curb sections removed under Item 202 instead of furnishing new stone curb. Use salvaged curb at locations designated by the Engineer. Place all salvaged sections of curb continuously without interspersing salvaged and new curb sections. Haul and store salvaged curb as directed by the Engineer. Cut, dress, set, and install joints in salvaged curbs according to the requirements for new curbs.

B. Granite Curb.

1. Cutting and Dressing. Ensure that 95 percent of all straight curb pieces are at least 5-feet long, with no pieces less than 42 inches. Use curb section a minimum of 30 inches for closure(s). For curves with a radius of 50 feet or greater, use radially jointed straight curb pieces between 36 and 42 inches long. For curves and corners with a radius of less than 50 feet, use pieces a minimum of 36-inches long, and dress, joint, and set pieces to the radii specified. For all curves and corners, use curb sections that are approximately uniform in length.

Dress all curb as specified in the plans to a depth of at least 6 inches below the gutter elevation. Dress the ends at right angles to the face for straight curb and radially for curb on curves. Place joints that are free of slack or hollow. Place joints smooth and free of projections after dressing the ends of any curb section that exceed 1/8 inch from the plane of the end of that section. Cut the edge next to the gutter to a 3-inch radius and dress the top to a 1/4-inch bevel rising from the exposed face. Use a pitching tool on the edge at the back to hand dress curb to the specified width.

2. Setting. Set the curb as shown on the Standard Drawing. Use a heavy rammer to settle the curb into place. Place and compact a minimum 4-inch wide aggregate backfill behind the curb to within 6 inches of the top. Bring the balance of the backfill to the level of the top of the curb for a distance of 2 feet behind the curb with soil or other acceptable material. Thoroughly tamp the backing in layers not exceeding 6 inches in thickness, loose measurement, with an approved tamper or rammer. Perform as much of the backfilling and tamping as is consistent with alignment of the curb at the time the stone is first set.

3. Joints. Set curbs such that below the dressed portions the space between ends of adjacent sections of curbing is 1/8 inch.

4. Reusing Existing as New Curb. If specifically allowed by the plans, and to the extent available, use acceptable stone curb sections removed under Item 202 instead of furnishing new stone curb. Use salvaged curb at locations designated by the Engineer. Place all salvaged sections of curb continuously without interspersing salvaged and new curb sections. Haul and store salvaged curb as directed by engineer. Cut, dress, set, and install joints in salvaged curbs according to the requirements for new curbs.

609.04 Cast-in-Place Concrete Curb and Combination Curb and Gutter.

A. Forms and Joints. Securely brace and hold forms to the line and grade shown on the plans. The Contractor may use flexible forms of steel or wood to construct curved curb with a radius of 200 feet or less. Immediately before placing concrete, clean the inner surface of the forms, and coat this surface with a form release agent.

Where curb and combination curb and gutter is not constructed integral with, or tied to, the base or pavement, construct 1/4-inch wide contraction joints at 10-feet intervals using steel separator plates, a grooving tool, or a saw according to Item 451. For combination curb and gutter, construct the joint to an average depth of 2 inches or more. For curb, construct the joint to an average depth of one-fifth or more of the curb height. When joints are made by the use of grooving tool or by sawing, use a 1/2-inch expansion joint strip the depth of the curb and gutter at the beginning and end of curves which radius is less than 200 feet and at the end of each day's operation. Where expansion joints occur in the abutting pavement, and end of curves which radius is less than 200 feet, and at the end of each day's operation, separate the section being placed with 1-inch thick 705.03 preformed filler.

Where the curb is integral with, or tied to, the base or pavement, construct the same type of joints as used in the pavement. Space joints identically with the joints in the base or pavement.

Leave curb forms in place until their removal will not crack, shatter, or otherwise injure the concrete. Do not seal transverse joints in cast-in-place concrete curb and combination curb and gutter.

If curbs are to later serve as a support for a finishing machine in the placing of a surface course, align supporting edges so that the distance between the curbs is within 1/2 inch from that specified.

B. Placing. Place concrete in forms prepared as described above, and vibrate the concrete to eliminate all voids.

Place concrete for curb that is integral with the concrete base or pavement while the base or pavement concrete is plastic. Where the presence of the finishing equipment on the forms at the end of the day's run prevents completing the curb, install No. 5 tie bars vertically in the pavement at 1-foot intervals and in a line 3 inches inside of and parallel to the pavement edge. Install these tie bars to within 1 1/2 inches of the subgrade or subbase and 2 inches above the concrete base or pavement surface. Water cure this horizontal construction joint between the concrete base or pavement and the curb, or membrane cure the concrete base or pavement and remove the membrane before placing the curb. Immediately before placing the concrete curb, brush mortar (consisting of one part cement to two parts sand with enough water to form a workable mortar) into the surface area of the hardened concrete pavement or base where the curb is to be placed. Do not allow the mortar to dry before placing the curb on top of it.

C. Slip-Form Placement. The Contractor may use a self-propelled machine to place concrete curb or curb and gutter. Force the concrete through a mold of the proper cross-section to obtain the proper density and cross-section. If using a track, set and secure the track on which the machine operates to the exact line and grade given by the Engineer. Use concrete of a consistency that provides the desired shape and remains as placed without slumping of the vertical faces.

1. The curb shall not vary by more than 1/4 inch from the proposed typical section.
2. The curb shall have a surface variation not to exceed 1/4 inch in a 10-foot length.
3. Place 1/2-inch construction joint material for the full depth of curbing whenever it becomes necessary to suspend the work for 30 minutes or more. Replace sections of curb exceeding the above tolerances or failing to meet other curb requirements specified herein at no cost to the City prior to placing the base, finished pavement or Asphalt Concrete, whichever is applicable.

D. Finishing. Without adding extra mortar, float the top of the curb to thoroughly compact the concrete and produce a smooth and even surface. Round the edges of the curb using a tool specially designed for this purpose. Immediately after removing the forms, rub the exposed face of the curb with a float to eliminate unnecessary tool marks. Provide a finished surface free of irregularities and waves, and uniform in texture.

Construct an approved opening through the curb at the elevation of the gutter, where a roof drain outlet pipe is encountered, which shall be made and finished at the same time as the curb and gutter is constructed.

Mark the top of curb to indicate location of water services (W) or water mains (M).

E. Protection. Cure concrete according to Item 451.

609.05 Asphalt Concrete Curb. Use one of the following methods, or other method approved by the Engineer, to furnish and place an asphalt concrete curb of the required cross-section.

A. Method A. After completing the surface course, paint or spray only the area to be occupied by the asphalt concrete curb with asphalt material conforming to 407.02. Apply the asphalt material at the rate of 0.15 gallon per square yard. Place the curb with a hand-operated or self-propelled machine consisting of a hopper and power-driven screw, which forces the material through an extrusion tube. Force the material through a die attached to the end of the extrusion tube to obtain the proper density and cross-section.

B. Method B. As an independent operation preceding the final rolling of the asphalt concrete surface course on which the curb is placed, place loose asphalt concrete of sufficient height. Shape the loose asphalt concrete by hand methods using suitable templates or by other means to produce the specified cross-section. Compact the loose asphalt concrete using a hand-operated mechanical vibrating tamper equipped with a compacting shoe of such shape that will produce the specified final cross-section dimensions of the curb.

609.06 Concrete Median and Traffic Island.

A. Forms and Joints. Securely brace and hold forms to the line and grade shown on the plans. Use approved flexible forms according to 609.04.

Where medians and traffic islands are not anchored to the pavement, construct contraction joints at 10-foot intervals using steel separator plates, a grooving tool, or saw according to Item 451. Construct joints to a minimum depth of 2 inches.

Where the medians or traffic islands are anchored to the pavement, construct the same type of joints in the median or traffic island as used in the pavement. Construct joints to a minimum depth of 2 inches using steel separator plates, a grooving tool, or saw according to Item 451. Space the joints identically with the joints in the pavement.

Leave forms in place according to Item 609.04.

B. Placing. Immediately before placing a concrete median or traffic island on subgrade, bring the subgrade to a thoroughly moistened condition by sprinkling with water at such times and in such a manner directed by the Engineer.

Place the concrete in forms prepared as described above, and vibrate the concrete to eliminate all voids.

C. Slip-Form Placement. The Contractor may use a self-propelled machine to place medians and traffic islands. Force the concrete through a mold of the proper cross-section to obtain the proper density and cross-section. If using a track, set and secure the track on which the machine operates to the exact line and grade given by the Engineer. Use concrete of a consistency that provides the desired shape and remains as placed without slumping of the faces.

D. Finishing. Without adding extra mortar, finish the top of the median or traffic island to a broom texture. Round the edges using a tool specially designed for this purpose. Immediately after removing the forms, rub the exposed faces with a float to eliminate unnecessary tool marks. Provide a finished surface free of irregularities and waves, and a uniform texture.

E. Protection. Cure concrete according to Item 451.

609.07 Method of Measurement. The City will measure Sandstone Curb, Curb, Combination Curb and Gutter, Asphalt Concrete Curb, and Granite Curb by the number of feet complete in place, measured along the front face of the curb section.

The City will measure Concrete Traffic Island and Concrete Median by the number of square yards or the number of cubic yards complete in place.

609.08 Basis of Payment. The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
609	Foot	Sandstone Curb
609	Foot	Curb, Straight 18”
609	Foot	Combination Curb and Gutter, Type ___
609	Foot	Asphalt Concrete Curb, Type ___
609	Foot	Granite Curb
609	Square Yard, or Cubic Yard	Concrete Traffic Island
609	Square Yard, or Cubic Yard	Concrete Median

ITEM 610 CELLULAR RETAINING WALLS

610.01 Description
610.02 Approval by the City
610.03 Materials
610.04 Manufactured Units
610.05 Excavation
610.06 Backfill
610.07 Wall Construction
610.08 Method of Measurement
610.09 Basis of Payment

610.01 Description. This work consists of constructing retaining walls composed of a series of cells formed by assembling precast reinforced concrete or galvanized metal units to form stable walls.

Concrete cellular walls consist of a series of rectangular or triangular cells formed by building up tiers of precast reinforced concrete units.

Metal cellular retaining walls consist of pairs of columns, one column in the plane of the front of the wall and the other column in the plane of the rear of the wall. The column pairs are spaced longitudinally with overlapping S-shaped facing and rear members, and transversely with overlapping U-shaped members.

610.02 Approval by the City. Submit to the Engineer for acceptance 15 days before the work is to begin, shop drawings of the units to be furnished, together with a proposed erection plan and schedule of operations. Only submit information for walls produced by manufacturers whose type of wall, and design of units comprising same, has been in successful commercial use for a period of at least 3 years.

610.03 Materials. Furnish manufactured units conforming to:

A. Concrete Cellular Wall. Use concrete conforming to Item 499, Class COC 1. Use reinforcing steel conforming to 509.02.

B. Metal Cellular Wall. Provide units made from galvanized metal sheets. Use base metal conforming to AASHTO M 218. Ensure that both sides of the sheets are galvanized by the hot-dip process. Provide an average spelter coating of not less than 2 ounces per square foot on each side of the sheet and a spelter coating of at least 1.8 ounces per square foot on any 2 1/4 × 2 1/2-inch area on each side of double exposed surfaces. Provide finished sheets that are free from injurious defects, such as blisters, flux, and uncoated spots.

Use metal sheets with a minimum thickness of 0.057 inch, unless otherwise shown on the plans.

Furnish three copies of the manufacturer's "Analysis and Coating Test Certificate" containing the following information covering each project or order on which galvanized metal walls are furnished.

1. Heat or heats used for units.
2. Analysis of each heat.
3. Amount of spelter coating for each heat.
4. Total units of each size and thickness.
5. Name of Contractor.
6. Name of street, road, or State route number, and section.
7. Project number or state purchase order number.

Send two copies to the Engineer. With each copy of the certificate, include a written statement, signed by a person having legal authority to bind the manufacturer, that the information and test results are correct and that the material complies with all contract requirements.

Furnish 5/8-inch diameter bolts, galvanized according to 711.02 and at least 1 1/4 inches long, measured from the underside of the bolt head.

610.04 Manufactured Units.

A. Concrete Cellular Wall. Cast concrete cellular wall units in substantial, unyielding steel forms. Properly assemble, clean, and oil the forms before placing concrete in the forms. During the placing and setting of the concrete, hold the forms rigidly in place on a smooth and level platform.

Secure the reinforcement to ensure that it remains in the required position while placing concrete.

Vibrate the fresh concrete to fill all space in the form with concrete, to densify the concrete, and to surround the reinforcement. Reject units with segregated areas.

Cure the units by covering with burlap that is kept wet at least 7 days or by applying steam for at least 24 hours.

All openings to be filled with nonshrink mortar per 705.22 including all lifting device voids.

The Engineer will reject reinforced concrete units for any of the following reasons:

1. Exposure of the reinforcing.
2. Defects that indicate imperfect mixing, placing, or curing.
3. Fractures and cracks.

B. Metal Cellular Wall. Fabricate galvanized metal cellular wall units so that units of the same nominal size are fully interchangeable. Do not drill, punch, or drift holes to correct manufacturing defects. Replace all units with improperly punched holes.

If possible, maintain a minimum forming radius of 1 inch. Hot-dip galvanize all units formed with less than 1-inch radius after forming.

610.05 Excavation. Excavate according to Item 203. Obtain the Engineer's approval that the bearing for the foundation of the walls is firm and to the proper elevation before erecting the wall.

610.06 Backfill. Below the elevation of the proposed ground line at the face of the wall, fill the cells formed by the units with soil as defined in 203.02.R. Above the elevation of the proposed ground line at the face of the wall, fill the cells with material conforming to Item 203 Granular Material Type B, except that the percent passing the No. 200 sieve shall not exceed 5 percent.

Place the material in layers that compact to a depth not to exceed 6 inches. Compact the material to the density established by the Engineer using approved tampers or compactors. Add water as directed by the Engineer.

Fill the space behind the wall according to 503.08, except as noted below.

Backfill around the wall and in the interior cells, concurrent with wall erection and as close to the wall elevation as allowed by the type of construction.

Do not use rolling equipment directly over a portion of the wall until placing at least 12 inches of compacted fill.

610.07 Wall Construction. Construct the wall types as follows:

A. Concrete Cellular Wall. Place sills to the required grade and alignment, and support the entire sill length on the foundation material. Do not shim the sill.

Place and interlock the headers perpendicular to the sills and stretches. Use templates to ensure that members are placed in the proper position and with the proper face batter.

Before placing sills, spread two layers of asphalt impregnated paper on all points of contact between the sills and the foundation material to ensure a uniform bedding.

After constructing two tiers of the wall, check and, if necessary, adjust the alignment, grade, and batter of the units, and backfill to this height before adding subsequent units. Complete the remainder of the wall.

B. Metal Cellular Wall. Use templates to ensure that members are placed in the proper position and with the proper face batter.

After placing the columns and constructing two tiers of the wall, check and, if necessary, adjust the alignment, grade, and batter of the units, and backfill to this height before adding subsequent units. Complete the remainder of the wall.

Carefully handle members, and remove and replace damaged members.

610.08 Method of Measurement. The City will measure Cellular Retaining Wall by the number of square feet of facial area complete in place.

610.09 Basis of Payment. Payment is full compensation for furnishing all materials, backfilling, including the interior filling, watering, and disposing of surplus materials.

The City will not pay for replacing any unit with improperly punched holes.

The City will not pay for removing or replacing members damaged during handling.

The City will pay for Excavation Not Including Embankment Construction under Item 203.

The City will pay for accepted quantities at the contract price as follows:

Item	Unit	Description
610	Square Foot	Cellular Retaining Wall

ITEM 613 LOW STRENGTH MORTAR BACKFILL

613.01 Description
613.02 Materials
613.03 Mix Proportioning
613.04 Mix Adjustment
613.05 Alternate Mixes
613.06 Mixing Equipment
613.07 Discharging the Materials
613.08 Placing Mortar
613.09 Method of Measurement
613.10 Basis of Payment

613.01 Description. This work consists of placing a low strength mortar backfill around conduits and at other locations. Perform the work for this item according to Item 499, except as modified below.

613.02 Materials. Furnish materials conforming to:

Cement ..... 701.01 or 701.04
Fly Ash..... 701.13

Furnish fine aggregate consisting of foundry sand, natural sand, sand manufactured from stone, gravel, or air-cooled blast furnace slag. Conform to the fine aggregate gradation requirements of 703.05. Use fine aggregate that is fine enough to stay in suspension in the mixture to ensure proper flow.

Furnish an air-entraining admixture that is designed for use in low strength mortar mixtures (also called controlled density fill or flowable fill).

613.03 Mix Proportioning. Furnish a low strength mortar mixture listed below or provide an alternate mix conforming to 613.05.

TABLE 613.03-1

	Type 1 [1]	Type 2	Type 3	Type 4
	lb/yd³	lb/yd³	lb/yd³	lb/yd³
Cement	50	100	0	0
Fly Ash, Class F	250	[2]	0	1500
Fly Ash, Class C [4]	0	0	400	500
Fine Aggregate [3]	2910	2850	2900	0
Water (Target)	500	500	425	850

[1] The Contractor may add an air-entraining agent specifically designed for the use in the low strength mortar mixture.
[2] Entrained air is substituted for fly ash in this mix. (Approximately 25 percent)
[3] Saturated Surface Dry
[4] Class C Fly Ash may be substituted for Class F Fly ash in Type 1 mixes with an approved mix design meeting the alternate mix design criteria of this specification.

These mixtures of materials are expected to yield approximately 1 cubic yard of material of a flowable consistency. Make small adjustments, as necessary, in the amounts of the materials in a mix to achieve the final product.

613.04 Mix Adjustment. Make one or more 1 cubic yard trial batches at different water contents to ensure a flowable material. The mixture is too dry if cracks develop in the mixture as it flows into place.

Adjust the proportions to maintain the total absolute volume. For large adjustments, see 613.05.

In order to expedite the settlement of a Type 1 mixture without entrained air, bleed water may appear on the surface immediately after the material is struck off. A delay in bleeding indicates there are too many fines in the mixture. The Contractor may reduce the fly ash quantity in increments of 50 pounds until the mixture is bleeding freely. Add approximately 60 pounds of sand to replace each 50 pounds increment of fly ash to maintain the original yield.

613.05 Alternate Mixes. The Contractor may submit alternate mixes for approval. Furnish the mix design and test data from an independent test laboratory 30 days before the intended usage for approval.

Submit an alternate mix design for all mixes that:

A. Vary more than 300 pounds in fine aggregate, 100 pounds in water, 20 pounds in cement, or 200 pounds in fly ash from the 613.03 mixes. These are considered large adjustments.

B. Have less than 50 pounds of cement in the Type 1 mixes or less than 100 pounds of cement in the Type 2 mixes.

C. Use alternate materials.

D. Contain foundry sand.

E. Contain fly ash not conforming to 701.13.

F. Use fine aggregate gradations other than 703.05.

The Contractor may use foundry sand if it meets the requirements of the Division of Surface Water Policy 400.007 "Beneficial Use of Non-Toxic Bottom Ash, Fly Ash and Spent Foundry Sand and Other Exempt Wastes," and all other regulations. Ten days before using a mixture containing foundry sand on the project, submit written permission from the Ohio EPA to the Engineer. The Contractor may elect to have an independent ODOT consultant pre-qualified in remedial design environmental site assessment review the proposed usage. The consultant will provide all documentation utilized to ensure that the proposed usage obeys all Ohio EPA regulations. The consultant shall coordinate all EPA required meetings, documentation, and testing requirements. The consultant shall certify the report or reports to the City.

Provide alternate mixes with an unconfined compressive strength between 50 and 100 pounds per square inch at 28 days when tested according to ASTM D 4832. Ensure that the long term (12-month) unconfined compressive strength is less than 100 pounds per square inch.

Ensure that the final mix has the required strength, fills the voids of the intended usages and sets up within 12 hours (4 hours for Type 3, Type 3 alternate mixes, Type 4, and Type 4 alternate mixes). The proportioning, yield, consistency, workability, compressive strength, and all other requirements are the sole responsibility of the Contractor.

613.06 Mixing Equipment. Provide the mixing capacity and delivery equipment to place the material without interruption as much as practical. Deliver and place Type 1 and 2 mixes or Type 1 and 2 alternate mixes from ready mixed concrete trucks, or deliver them from a batch plant.

Deliver and place Type 3 and 4 mixes or Type 3 and 4 alternate mixes using volumetric mobile mixers. Calibrate volumetric mixers properly and sufficiently mix the materials in the mixer to produce a uniform material.

613.07 Discharging the Materials. Discharge the mixture within 2.5 hours after adding water.

613.08 Placing Mortar. Unless specifically shown on the plans, do not place the mortar within 3 feet of the subgrade elevation. Discharge the flowable material from the mixer by any reasonable means into the space of the plan intended usage. Bring the fill material up uniformly to the fill line shown on the plans. The Contractor may begin placing the other fill material over low strength mortar backfill material as soon as the surface water is gone. The Engineer reserves the right to reject the mix if a flowable mixture is not produced.

Before placing the low strength mortar backfill as backfill for Item 603 Conduit, secure the conduit to prevent it from floating during placement of the flowable material.

613.09 Method of Measurement. The City will measure Low Strength Mortar Backfill by the number of cubic yards completed and accepted in place, computed from the plan lines. The City will not pay additional compensation for over excavated areas or for a change in the material blends.

613.10 Basis of Payment. The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
613	Cubic Yard	Low Strength Mortar Backfill
613	Cubic Yard	Low Strength Mortar Backfill (Type ___)

ITEM 614 MAINTAINING TRAFFIC

614.01 Description
614.02 Traffic Facilities
614.03 Traffic Control - General
614.031 Permit
614.032 Notification
614.035 Storage of Equipment, Vehicle and Material on Highway Rights of Way
614.04 Work Zone Marking Signs
614.05 Road Closed
614.055 Surface Condition Signs
614.06 Detour Signing
614.07 Traffic Maintained
614.071 Existing Parking Meters
614.08 Flaggers
614.09 Law Enforcement Officer
614.10 Work Zone Traffic Signals
614.11 Work Zone Pavement Markings
614.115 Work Zone Raised Pavement Markers
614.12 Pavement Marking Operations
614.13 Asphalt Concrete for Maintaining Traffic
614.14 Performance
614.15 Method of Measurement
614.16 Basis of Payment

614.01 Description. This work consists of maintaining and protecting vehicular, bicycle and pedestrian traffic according to these provisions. For through traffic, the Special Provisions or the Plans will designate whether the roadway will be closed with detours, roads and run-arounds provided or whether traffic will be maintained through all or portions of the project.

614.02 Traffic Facilities. Construct and maintain facilities for vehicular, bicycle, and pedestrian traffic of the roadway, including all walks, bicycle lanes, roads, bridges, culverts, and traffic control devices. The City will maintain public roadways used as a detour beyond the work limits of the contract.

A. For local traffic, provide and safely maintain drives, roads, run-arounds, walks, structures, and other facilities. Provide safe vehicular, bicycle, and pedestrian ingress and egress for all property adjacent to any improvement. Provide approaches and crossings of intersecting roadways and bicycle lanes, and maintain them in a safe condition. Maintenance includes snow and ice removal as needed.

B. When the roadway under construction is being used by through traffic, including periods of suspension of the Work, maintain it so that it is smooth, free from potholes, ruts, ridges, bumps, and other pavement deficiencies. Furnish proper maintenance of traffic facilities and proper provisions for traffic control as per 105.14. For the portions of roadway being used, provide the necessary outlets to allow free drainage. Maintain pipe trenches or other openings left in hard surface pavements with material of comparable quality. Contractor maintenance responsibilities, including pothole patching and wedging and signing of steel road plates, begins for a section of roadway when the Contractor begins the Work in that section and ends with the acceptance of the Work under 109.11 or 109.12. The two directions of a divided roadway are considered separate roadway sections and the start of Work on one direction does not begin maintenance responsibilities on the other direction.

C. Remove from the Project as necessary, abrasives and salt residues left by City or Local Government snow and ice control operations.

D. Ensure positive drainage into structures that have inlet windows without grates during pavement overlay operations when traffic will be maintained on a pavement course lower than the inlet window. Provide a minimum of 2 inch holes spaced at 2 feet or a minimum of three 4 inch holes spaced at 4 feet drilled into the vertical wall of the existing drainage structure below the inlet window. Place steel or iron plating of at least ¼ inch thickness that completely covers the drilled holes prior to construction of the finished pavement course.

E. Any time a maintenance or construction activity impacts a Pedestrian Access Route (PAR) so that an area of the PAR is inaccessible, a temporary PAR shall be identified or created if necessary. The temporary PAR shall define a route bypassing the area under construction or maintenance and returning to the accessible area of the PAR. The temporary PAR shall comply with the City of Columbus ADA Rules and

Regulations. Sidewalk closure shall be marked with an approved sign at each end of the closure. Barricades shall be constructed at the point of closure. At the barricades and at each turn in the temporary PAR, a pedestrian detour sign and an arrow indicating the direction of the PAR shall be provided. The signage requirements shall apply for travel in both directions along the PAR. Should a compliant alternate PAR not be available, a temporary compliant PAR shall be constructed. This may require temporary curb ramps into an area of the street that is closed to vehicle traffic. Barricades shall be erected to prevent vehicles from entering the temporary PAR.

614.03 Traffic Control General. Conform to the requirements of the plans, Standard Drawings shown on the plans, and the OMUTCD, for the installation, maintenance, and operation of all traffic controls and traffic control devices. When the plans or Standard Drawings do not cover a specific traffic control situation, submit a Maintenance of Traffic Plan to the City for approval.

Do not begin construction until all traffic controls and traffic control devices are in place and approved by the Engineer. When performing the construction in phases, have the required traffic control for each phase in place and approved by the Engineer before construction of that phase begins.

Furnish cones, drums, portable sign supports, Type 3 barricades, portable changeable message signs, arrow boards, and impact attenuators that are pre-qualified according to current specifications.

Use cones, drums, signs, sign supports, barricades and other traffic control devices that are certified to meet NCHRP 350 or the appropriate MASH Test Level. Do not use heavy non-yielding devices or supports that are not crashworthy.

Use Type H reflective sheeting complying with 730.192 for faces of orange construction signs, barricades, vertical panels, object markers, and Type G or Type H for stripes on glare screen panels and regulatory signs. Use fluorescent orange reflective sheeting for all orange construction signs, object markers, and stripes on glare screen paddles. Use standard orange or fluorescent orange reflective sheeting for the orange portions of drums, cones, barricades and vertical panels.

Furnish orange drums with reboundable reflective sheeting complying with the requirements of 730.191 and in conformance with the OMUTCD. Drums of colors other than orange shall not be permitted on the project. Provide Type C steady burning lights for all drums used during hours of darkness. Ensure that owner identification markings on construction drums are no more than 1 inch in character height and are located at least 2 inches below the reflectorized bands or on the top or bottom horizontal surfaces of the drum. Ballast the drums according to the manufacturer's recommendations or as directed by the Engineer.

Furnish traffic cones, for daylight hours only, consisting of a highly visible orange predominant color. Traffic cones of colors other than highly visible orange shall not be permitted on the project.

Ensure that the pavement markings for traffic maintenance conform to Item 614.11.

Furnish warning signs in advance of channelizing devices such as barricades, drums, vertical panels, and cones.

Furnish object markers that are a minimum size of 6 x 12 inches and that consists of reflective sheeting adhered to an aluminum or plastic plate.

Keep retroreflective materials clean and in good condition.

614.031 Permit. Apply for a permit at the City's Division of Infrastructure Management a minimum of 5 working days prior to the closure of any portion of a street. Present a copy of the plans and a Maintenance of Traffic Plan, with phasing, at the time of application. The Department of Public Service will then review the permit application and the City will issue a permit. Keep the original permit, signed in red ink, on the job at all times.

Failure to comply with the provisions of this permit, including, but not limited to, working outside the permitted hours of work and/or the failure to properly install the required traffic control, is a violation of City Code 903 and will result in the revocation of this permit and a fine of up to $1,000.00 and up to 6 months in jail. No work will be allowed in the City right-of-way without a valid permit.

The Contractor may restore a revoked permit with the written permission of the Division of Infrastructure Management, and the Division of Police.

614.032 Notification. Notify the Engineer, the Temporary Traffic Control Coordinator and Paving The Way, in writing, of all traffic restrictions and upcoming maintenance of traffic changes on a weekly basis. The Temporary Traffic Control Coordinator is the authorized representative of the City of Columbus working under the supervision of the Administrator of the Division of Traffic Management. The Temporary Traffic Control Coordinator is the duly authorized agent of the City of Columbus acting within the scope of its authority for purposes of engineering, directing and coordinating temporary traffic control (for motorists, bicyclists, and pedestrians) for work within the right-of-way and typical or non-typical events.

When detours are planned, provide this notification at the preconstruction meeting or 10 working days in advance of construction. When lane and ramp closures for 2 or more weeks are planned, provide this notification at least 2 weeks in advance of such closures. When lane and ramp closures are planned for less than 2 weeks, provide this notification at least 3 working days in advance of such closures.

Information shall include but not be limited to all construction activities that impact traffic at present and in the next 30 days. Prepare the report in a format approved by the Engineer. Designate an individual who will be responsible to prepare this report at the preconstruction meeting.

Report any unforeseen impacts to traffic to the Engineer as soon as identified by the Contractor.

614.035 Storage of Equipment, Vehicle and Material on Highway Rights of Way. Unless otherwise permitted by the Engineer or Temporary Traffic Control Coordinator, locate all equipment, vehicles, and material stored or parked on roadway rights-of-way.

At night, encompass any such equipment, vehicles or material with drums, equipped with Type A warning lights.

For locations with traffic approaching from more than one direction or side (e.g., medians, between mainline and ramps, etc.), ensure the requirements are met for all traffic approaches.

614.04 Work Zone Marking Signs. Furnish, install, maintain, and subsequently remove work zone marking signs and their supports within the work limits according to the following requirements:

A. On roadways with existing edge lines, erect a NO EDGE LINES sign in advance of any section of roadway lacking OMUTCD standard edge line markings. Ensure these signs are in place before opening the roadway to traffic. Erect these signs on each entrance ramp, 25 to 200 feet beyond the far shoulder or curb line of intersection through roads to warn entering or turning traffic of the conditions, and at least once every 2 miles along the roadway. Remove these signs when they no longer apply.

B. Erect a DO NOT PASS sign at the beginning and a PASS WITH CARE sign at the end of each no passing zone lacking OMUTCD standard center line markings.

C. Provide Type A flashing lights for all advance warning signs and additional lights as directed by Engineer.

614.05 Road Closed. When the roadway is closed to traffic, furnish, erect, maintain, and subsequently remove advanced warning signs and supports, ten (10) foot Type III barricades with 2 ROAD CLOSED signs and a DO NOT ENTER sign on the barricades, and Type B yellow flashing lights at the total closure point. Dual mount portable six (6) foot Type III Barricades with ROAD CLOSED LOCAL TRAFFIC ONLY, NO OUTLET, and Detour signing at the intersection prior to the total closure point and as directed by Engineer.

Throughout construction, furnish, erect, maintain, and subsequently remove all signs, lights, barricades and other traffic control devices required by the OMUTCD, plans, or Standard Drawings for the maintenance of local traffic.

614.055 Surface Condition Signs. Erect a GROOVED PAVEMENT sign 100 feet in advance of any section of roadway where traffic must travel on a planed surface. Ensure these signs are in place before opening the roadway to traffic. Erect these signs on each entrance ramp and at intersections of through roads to warn entering or turning traffic of the conditions. Payment for these signs to be included in Item 614 Maintaining Traffic.

614.06 Detour Signing. When the Contract Documents provide a pay item for Detour Signing and the plans provide a detour-signing plan, furnish, maintain, and subsequently remove all required detour signing and supports according to the detour signing plan and/or as directed by the Engineer.

614.07 Traffic Maintained. Where the roadway under construction is being used by through traffic, including periods of suspension of the work, furnish and maintain pavement markings, lights, construction signs, barricades, guardrail, sign supports, and such other traffic control devices. Maintain pre-existing roadside safety hardware at an equivalent or better level than existed prior to project implementation. Also, provide law enforcement officers, watchmen, and flaggers in accordance with the Contract Documents and as necessary to maintain safe traffic conditions within the work limits as directed by the Engineer.

The Engineer will approve the erection and removal of any regulatory signs not shown on the plans.

Keep existing signs including 630.09 Specific Service and Tourist-Oriented Directional Signs and traffic control devices in use within the work limits during the construction period unless otherwise indicated on the plans. If existing signs, including street name signs, and other traffic control devices must be relocated or modified as a consequence of the work, provide suitable supports and modify the devices with prior approval of the Engineer and the concurrence of the maintaining agency. Keep existing STOP, YIELD, ONE WAY, or DO NOT ENTER signs functioning at all times. The Contractor may adjust the position of these signs with the Engineer's approval. Relocate existing signs that must be adjusted laterally according to the OMUTCD. Restore relocated or modified signs to the position and condition that existed before construction as directed by the Engineer. When signs are to be covered, provide an opaque covering that covers the entire message, symbol and all of the sign within the border. Do not use fastenings that damage the sign or reflective face; however, the Contractor may use rivets to attach rigid overlay panels. Do not apply adhesive tapes directly to the face of the sign.

When an existing signal operation must be interrupted for a period of time, provide a traffic control method approved by the Engineer.

Whenever it is necessary to divert the flow of traffic from its normal channel into another channel, clearly mark the channel for such diverted traffic with cones, drums, barricades, vertical panels, pavement markings, or arrow boards. Also use this method of marking where working adjacent to the part of the roadway in use by the public.

Obtain the approval of the Engineer before closing a traffic lane or establishing a one-way traffic operation.

614.071 Existing Parking Meters. If the Contractor needs to take an existing parking meter out of service, the City will charge a daily fee, equal to the hourly rate on the meter times the number of hours the meter is enforced. In addition, if meter heads must be removed, the City will charge a fee for removal of each meter. The City will collect these charges in advance from the Contractor when the Division of Infrastructure Management-Permit Office issues a sidewalk/street excavation/occupancy permit.

Notify the City a minimum of 48 hours prior to the beginning of work; Saturday and Sunday do not count in the notification time whenever a meter needs to be removed. The City will remove the meter head and will pre-mark the meters for re-installation. Ensure the posts are plumb to 1/4 inch. Notify the Parking Meter Supervisor at least 48 hours prior to the beginning of the re-installation; Saturday and Sunday do not count in the notification time.

614.08 Flaggers. Whenever two-way, one-lane traffic is established, use at least two flaggers unless the Engineer authorizes otherwise, and erect signs, cones, barricades, and other traffic control devices according to the OMUTCD. Reflectorize traffic control devices as previously noted. Maintain positive and quick means of communication between the flaggers at the opposite ends of the restricted area.

Equip flaggers according to the standards for flagging traffic contained in the OMUTCD. During a flagging operation, other than an intersection or a spot location best controlled by a single flagger, ensure that each flagger uses a STOP/SLOW paddle conforming to the OMUTCD. Mount the paddle on top of a 6 1/2-foot handle. Ensure that each face of the paddle is made of Type G reflective sheeting meeting the requirements of 730.19. Do not allow flaggers to perform other work activities while they are flagging. The Contractor may, instead of using flaggers, or supplemental to them, furnish, install, maintain and operate a traffic signal or signals, for the purpose of regulating traffic according to a written agreement approved by the Engineer.

Use an arrow board in the closure of any through lane of traffic, except in a two-way, one-lane or shifting of lanes traffic pattern.

During hours of darkness, fully illuminate flagger stations with portable lighting separate from the lighting for the work area. Ensure that all devices meet nighttime requirements per the OMUTCD and all OSHA standards.

614.09 Law Enforcement Officer. In accordance with the Contract Documents, furnish the services of a law enforcement officer and, if specified, a patrol car equipped with flashing lights.

614.10 Work Zone Traffic Signals. If shown on the plans, furnish, erect, maintain, and subsequently remove signal equipment conforming to Items 632 and 732, and signal controller equipment of a proper type and capacity to provide the required operation. Subject to the Engineer's approval, the Contractor may use new equipment that is to be installed later on the project, or may install used equipment in good condition provided such used equipment meets current City specifications. The performance test in 632.28 and the working drawing requirements of 632.04 are waived. Recondition used equipment as necessary to ensure proper operation. Operate work zone traffic signals conforming to the requirements of the OMUTCD and subject to the approval of the Engineer.

Procure and pay for electric power for work zone traffic signals. Do not alter the operation of an approved work zone traffic signal without the Engineer's approval. Correct any malfunctions or failures without delay. Cover or remove work zone traffic signals not in use.

614.11 Work Zone Pavement Markings. Furnish, install, maintain, and, when necessary, remove work zone retroreflective pavement markings on existing, reconstructed, resurfaced or temporary roads within the work limits, according to the following requirements:

A. Acceptability and Expected Duration. The Engineer will evaluate the markings according to the three performance parameters contained in ODOT Supplement 1047. Repair or replace the markings when the numerical rating is seven or lower for durability, visual effectiveness and night visibility. Repair or replace unsatisfactory markings immediately and at no additional cost to the City, if the markings were in place for 120 calendar days or less. The City will compensate under the applicable contract pay item for work zone pavement marking for the ordered replacement of worn markings after 120 calendar days under traffic.

B. Work Zone Marking Specifications. Equip traffic paint striping equipment for Class I and Class III markings with a computerized Data Logging System (DLS) conforming to 641.04 when the length of marking exceeds 0.5 miles of continuous line equivalent. Furnish the Engineer daily, biweekly and final DLS reports according to 641.04.

Unless otherwise shown on the plans or directed by the Temporary Traffic Control Coordinator, the Contractor may use 740.02 Type 1 or Type 1A paint or 740.06 Type I or Type II preformed material or 740.10 Spray Thermoplastic Pavement Marking Material for work zone pavement markings. Either 740.06 or 740.10 shall be used for all temporary markings which will be in place or installed between November 1st and April 15th.Furnish painted markings according to Item 642 except that:

1. For Class I or Class II work zone pavement markings, use the specified application rate from Table 614.11-1.

TABLE 614.11-1

Type of Pavement Marking	Line Width (inch)	
	5	10
	Gallon per Mile of Line	
Solid Line	27.5	55
10-foot Dashed Line	6.9	--
4-foot Dashed Line	2.8	--
Dotted Line	9.1	--
Arrows, Symbols, and Words	1.4 gallons per 100 square feet	
Glass Beads 740.09, Type A	15 pounds per 100 square feet	

2. For Class III work zone markings, use the specified application rate from Table 614.11-2.

TABLE 614.11-2

Type of Pavement Marking	Line Width (inch)	
	5	10
	Gallon per Mile of Line	
Solid Line	15	30
10-foot Dashed Line	4	--
Dotted Line	5	--
Arrows, Symbols, and Words	0.75 gallons per 100 square feet	
Glass Beads 740.09, Type A	7.5 pounds per 100 square feet	

Ensure that Type I and II preformed material conform to 740.06, except do not place any preformed material containing metal on any surface unless it will be removed later. Remove work zone pavement markings of 740.06 preformed material before placement of Item 642 or Item 644 surface course markings at that location. Ensure that preformed material conforms to Item 645.

C. Work Sequence. Ensure that work zone markings are complete and in place on all pavement, including ramps, before exposing the pavement to traffic. When work zone markings conflict with the traffic pattern, remove them according to 641.10.

D. Layout and Premarking. Layout and premark all Class I and Class III Markings according to 641.06. Obtain the Engineer's approval of the layout and premarking lines before marking operations are started.

E. Tolerances. Place lines for final surfaces according to the tolerances of 641.07. On surfaces other than final, the City will allow tolerances twice that in 641.07.

F. Classes of Work Zone Pavement Markings.

1. Class I Markings (Full Pattern, Full Rate). Use Class I Markings on all surfaces exposed to traffic for more than 14 days prior to application of final markings and to over-winter the project, with the following exception: Do not use Class I Markings on a surface course if thermoplastic or spray thermoplastic final markings are to be applied to the surface course. If thermoplastic or spray thermoplastic final markings are to be applied to the surface course, use Class III Markings on that course. Apply Class I work zone markings to the standard dimensions as defined in Item 641, except as follows:

a. Edge Lines. Class I edge lines shall match existing edge lines in width, 5 inches.

b. Lane Lines. Class I lane lines shall match existing lane lines in width, 5 inches.

c. Channelizing Lines. Class I channelizing lines shall match existing channelizing lines in width, 10 inches.

2. Class II Markings (Abbreviated, Full Rate). Use Class II Markings for short-term use when traffic is to be maintained in parallel lanes nominally in the same location as permanent lanes and where tapers or transitions are not required or other features will not likely divert traffic from the intended path. Class II Markings are limited to center lines, lane lines and gore markings defined as follows:

a. Center Lines. Class II center lines consist of single, yellow 5-inch wide by a minimum of 4 feet long dashes spaced at a maximum of 40 feet intervals. No Passing Zones must be marked with Class I or Class III markings or final markings within 3 calendar days according to 614.11.H.1. Passing Zones must be marked with Class I or Class III Markings or final markings within 14 calendar days according to 614.11.H.2.

b. Lane Lines. Class II lane lines shall be white and shall match existing lane lines in width, 5 inches, by a minimum of 4 feet long dashes spaced at a maximum of 40 feet intervals. Class II Lane Line Markings must be marked with Class I or Class III Markings or final markings within 14 calendar days according to 614.11.H.3.

c. Gore Markings. Class II gore markings are continuous, white 20-inch wide lines in a chevron crosshatched pattern placed within the theoretical gore of an exit ramp or diverging roadways. Class II Gore Markings must be marked with Class I or Class III Markings or final markings within 14 calendar days according to 614.11.H.3.

3. Class III Markings (Full Pattern, Low Rate). Use Class III Markings on surface courses that are expected to receive thermoplastic or spray thermoplastic within 30 days. Class III Markings use a lower application rate which reduces the surface preparation needed prior to application of thermoplastic or spray thermoplastic final markings. If Class III markings have been applied and weather conditions are expected to prevent thermoplastic or spray thermoplastic final markings application for 30 days or more, re-apply Class III Markings (if thermoplastic or spray thermoplastic final markings application is expected to occur within 30 days) or apply Class I Markings as necessary to carry the project through the season or over the winter.

Apply Class III work zone markings to the standard dimensions as defined in Item 641 except as follows:

a. Edge Lines. Class III edge lines shall match existing edge line in width, 5 inches.

b. Lane Lines. Class III lane lines shall match existing lane line in width, 5 inches.

c. Channelizing Lines. Class III channelizing lines shall match the existing channelizing line in width, 10 inches.

G. Conflicting Markings. Conflicting markings are considered to be any markings not actively in use, not behind channelizing devices or portable barrier and/or could be misinterpreted by the traveling public or cause confusion to the driver as determined by the Engineer. Before placing work zone markings, remove or cover all conflicting existing markings visible to the traveling public.

1. Removal and Covering of Markings.

a. Removal Methods. Remove the markings so that less than 5% of the line remains visible. Repair damage to the pavement that results in the removal of more than 1/8 inch of pavement thickness.

Use water blasting to remove markings on all asphalt or concrete pavement surfaces.

Use water blasting for removal of all pavement markings in preparation for placing Item 421 Microsurfacing.

A grinder may only be used to remove markings on temporary pavement or pavement that will be covered or removed prior to project completion (e.g., intermediate asphalt course). When a grinder drum is mounted to a skid steer loader, the drum must be able to accommodate a minimum of 150 teeth.

b. Covering Conflicting Markings. With the Engineer's approval, use removable, non-reflective, preformed blackout tape to cover conflicting markings. Remove or replace the blackout tape within 15 days of installation. Furnish products according to ODOT's Qualified Products List (QPL).

2. Raised Pavement Markers. Remove the prismatic retro-reflector within any raised pavement marker that is in conflict with the work zone pavement markings. When the work zone pavement markings are removed and the raised pavement marker is no longer in conflict, thoroughly clean the recessed reflector attachment area of the casting and install a new prismatic retro-reflector of the same kind and color. The cost for this work is incidental to the various pay items.

H. Allowable Duration of Work Zone Markings.

1. No Passing Zones. When existing permanent no-passing-zone markings are removed or obliterated as the result of a construction operation (pavement grinding, asphalt concrete pavement overlays, etc.) and the section of pavement continues to be used by the traveling public, place Class I Center Line Markings or final center line markings as specified by the plans within 3 Calendar Days unless thermoplastic, or spray thermoplastic final markings are to be applied on the surface course. If thermoplastic, or spray thermoplastic final markings are to be applied on the surface course, place Class III Center Line Markings or final center line markings as specified in the plans within 3 Calendar Days.

a. Subsequent Work in No Passing Zones. If, after the original markings are removed or obliterated, the Contractor returns to the subject no passing zone and places a plan-specified pavement course within the 3Calendar Day limit, or performs work in preparation for a subsequent pavement course, the Contractor shall have temporarily satisfied the conditions of the previous paragraph. In this event, the 3Calendar Day limit will begin again.

b. Liquidated Damages. For each Calendar Day beyond 3 days that this work remains incomplete, the City will assess liquidated damages in the amount of $1000 per Calendar Day. The City will treat the time for the completion of no-passing-zone markings as an interim Completion Date.

2. Passing Zones. Sections of pavement where passing is permitted in both directions must be marked with Class I Center Line Markings or final center line markings as specified by the plans within 14 Calendar Days unless thermoplastic, or spray thermoplastic final markings are to be applied on the surface course. If thermoplastic, or spray thermoplastic final markings are to be applied on the surface course, place Class III Center Line Markings or final center line markings as specified in the plans within 14 Calendar Days.

3. Allowable Duration of Class II Lane Lines and Gore Markings and Absence of Edge Lines. Any time existing permanent lane lines, gore markings, or edge lines have been removed or obliterated as the result of a construction operation (pavement grinding, asphalt pavement overlays, pavement widening, etc.) and the section of pavement continues to be used by the traveling public, place Class I Markings or final markings as specified by the plans within 14 Calendar Days unless thermoplastic, or spray thermoplastic final markings are to be applied on the surface course. If thermoplastic, or spray thermoplastic final markings are to be applied on the surface course, place Class III Markings or final markings as specified in the plans within 14 Calendar Days.

a. Subsequent Work. If, after the original markings are removed or obliterated, the Contractor returns to the subject section of pavement and places a plan-specified pavement course within the 14 Calendar Day limit, or performs specified work that requires a lane closure (except routine maintenance required by 614.02), the Contractor shall have temporarily satisfied the conditions of the previous paragraph. In this event, the 14 Calendar Day limit will begin again.

b. Liquidated Damages. For each Calendar Day beyond 14 days that this work remains incomplete, the City will assess liquidated damages in the amount of $1000 per Calendar Day. The City will treat time for the completion of these markings as an interim Completion Date.

i. Continuous Project. If a section of pavement is in a continuous part of the project, then a new 14 day limit for renewed work on a section applies to all sections in that part.

ii. Project in Sections. If the project is in parts and the traveling public could not discern the parts as one continuous project, then a new 14-day limit in one part will not apply to the other parts.

iii. Freeways and Divided Highways. Treat the two directional sides of a freeway as separate parts. Work on one side of a freeway does not create a new 14-day limit for the other side.

I. Removal of Work Zone Markings. Remove work zone retroreflective pavement markings when necessary. Accomplish removal of work zone pavement markings by using removal methods specified in 614.11.G.1.a for removal of existing markings.

614.115 Work Zone Raised Pavement Markers. Furnish, install, maintain and subsequently remove work zone raised pavement markers (WZRPMs). Work zone raised pavement markers may serve as a substitute for, or supplement to, work zone pavement markings. They are provided in both yellow and white versions to match the appropriate pavement marking color.

White units provide reflectorization in one direction while yellow units may provide reflectorization in either one direction or two. They are available as units which are readily visible both night and day as a result of retroreflectors and brightly colored (white or yellow) housing (Type A) or visible only at night due to their retroreflectors (Type B).

A. Materials. Furnish materials according to the ODOT's Approved List.

Only use adhesives that are recommended by the reflector manufacturer and are not epoxy.

Provide markers of sufficient strength and properly shaped so as not to be dislodged or broken by impacts from vehicle tires, including those of high pressure truck tires loaded to 4500 pounds.

Provide reflectors having an area of 0.35 square inches for Type A or 3.0 square inches for Type B with brightness or specific intensity (when tested at 0.2 degree angle of observation and the following angles of incidence) meet or exceed the following:

WZRPM SPECIFIC INTENSITY

Type	Incidence Angle	White	Yellow
A	0	1.0	0.6
A	20	0.4	0.24
B	0	3.0	1.8
B	20	1.2	0.72
B	45	0.3	0.2

Angle of incidence: Formed by a ray from a light source to the marker and the normal to the leading edge of the marker face (also horizontal entrance angle)

Angle of observation: Formed by a ray from a light source to the marker and the returned ray from the marker to the measuring receptor

Specific intensity: The mean candlepower of the reflected light (at given incidence and divergence angles) for each footcandle at the reflector (on a plane perpendicular to the incident light)

Type A markers, when viewed from above, have a visible area of not less than 14 square inches. When viewed from the front, parallel to the pavement, as from approaching traffic, Type A markers have a width of approximately 4 inches and a visible area of not less than 1.5 square inches.

B. Patterns. The patterns of WZRPMs required for the various types of pavement markings are shown in Table 614.115-1.

TABLE 614.115-1

SUPPLEMENTAL DELINEATION (TYPE A OR B)

Type of Line	Color	Spacing
Edge Line	1-way white or yellow	20' c/c
Lane Line	1-way white	40' c/c or at center of gap
Dashed Center Line	2-way yellow	40' c/c or at center of gap
Double Center Line	2-way yellow	2 units; 20' c/c
Channelizing Line	1-way white	10' or 20' c/c
Exit Gore (Outline)	1-way white	10' c/c

SIMULATED DELINEATION (TYPE A ONLY)

Type of Line	Color	Spacing
Edge Line	1-way white or yellow	10' c/c
Edge Line on 1-Lane, 2-Way	1-way white and 1-way yellow	white & yellow units back-to-back [2] 10'
Lane Line	1-way white	3 units at 5' c/c 30'gap
Dashed Center Line	2-way yellow	3 units at 5' c/c 30' gap
Double Center Line	2-way yellow	2 units [1]; 10' c/c
Channelizing Line	1-way white	5' c/c
Exit Gore (Outline)	1-way white	5' c/c

[1] Place units side by side about 4 inches apart.
[2] Face the proper color and reflector to the oncoming traffic. Place the units back to back about one quarter inch apart.

C. Installation. Attach work zone raised pavement markers to clean, dry and sound pavement. Remove all loose gravel, sand and dirt from the area of the line. The minimum pavement temperature for installation is 50 °F. When markers are being attached to new concrete pavement with curing compound remaining, remove the curing compound membrane by sandblasting or other mechanical cleaning method. Install markers in accordance with the manufacturer's recommendations.

Work zone raised pavement markers are not suitable for use from October 15 to April 1. If the Contractor elects to start or continue work zone pavement markers during this period, and they fail or are subsequently removed or destroyed by snow and ice control activities, immediately, at his expense, provide a substitute traffic guidance system which is effective during day and night and which is acceptable to the Engineer. Other than for replacement of failed WZRPMs, new installations of WZRPMs are not permitted from October 1 to April 1.

Place markers accurately to depict straight or uniformly curving lines. The longitudinal location of WZRPMs are described in Table 614.115-1 except that the spacing of an individual WZRPM may be varied by as much as 2 feet or 10 percent of the nominal spacing in order to avoid poor pavement conditions, but the average spacing remains unchanged. Poor pavement conditions include separated joints, cracks, deteriorated pavement, usually uneven pavement or where pavement marking material will interfere with the bond.

The lateral location of WZRPMs follows:

1. Edge Lines. Install the WZRPM 12 inches outside the work zone pavement marking, if any, or the theoretical edge of the lane. This offset may vary +6 inches as necessary to avoid poor pavement conditions.

2. Lane Lines and Dashed Center Lines. Install the WZRPM in the center of the gap between pavement marking dashes, if any. If a pavement joint exists, locate the marker approximately 2 inches clear from the joint (and to the left of it for lane lines). Otherwise, center the WZRPM on the theoretical edge of the lane.

3. Double Center Line. Install each WZRPM of the pair in line with the appropriate pavement marking stripe, if any. If the edge of lane is demarcated by a crack or joint, the pair of WZRPMs straddle the joint and install each approximately 2 inches clear from the joint. Otherwise center the pair on the theoretical edge of lane.

4. Channelizing Line. Install the WZRPM in line with the pavement marking stripe or immediately adjacent to the line, except when used at exit gore outlines where the WZRPM is installed within the painted gore vee and approximately 12 inches from the pavement marking stripe. Do not install WZRPMs directly on a painted line.

D. Replacement. Maintain WZRPMs in good condition. A marker will be considered to have failed when the marker is broken, the marker is worn to the extent that daytime visibility is significantly diminished or of an unacceptable color (type B only), the reflector is broken or detached, the marker is detached from the adhesive, the adhesive is detached from the pavement or the marker or reflector is covered by tar or paint.

Individual replacement of each failed marker as it occurs is not recommended due to increased exposure of workers to traffic. However, maintain the following minimum levels of marker effectiveness:

1. For a given line, no more than 20 percent of the WZRPM units failed in any manner;
2. For a segment of any line, the number of failed units does not exceed the maximums permitted in Table 614.115-2.

TABLE 614.115-2

Line Type	Normal Spacing (Feet)	Segment Length (Feet)	Normal No. Contained in Segment	Maximum No. Permitted to Fail
Edge	1020	5 100	6	3
Center, Double/Solid	20 10	100 50	12	6
Lane or Dashed Center	40 5	200 1-Stripe	6	3
Channelizing	20105	100 50 25	6	3

Replace all failed units within any line or segment before conditions deteriorate below the minimums established in Table 614.115-2. Replace all failed units within the line or segment within 24 hours after notification by the Engineer.

E. Removal. Accomplish removal of work zone raised pavement markers in such a manner that no adhesive remains on the pavement. Do not cause permanent pavement surfaces to be scarred, broken or significantly roughened.

614.12 Pavement Marking Operations. Perform moving marking operations with a truck equipped with necessary flashers, signs, crash attenuator and arrow board, and protect the operations with a similarly equipped vehicle or vehicles separated a sufficient distance to provide adequate advance warning. Use the extreme left or right lane for the marking operation when possible. Where three or more lanes exist in one direction, perform the marking operation so that traffic passes on one side only.

Protect stationary marking operations in intersections, school zones, gores and other areas with traffic control devices such as advance warning signs, arrow boards, and cones.

For stationary operations such as loading material and cleaning equipment, make every effort to have all equipment completely off the traveled way. When equipment cannot be removed from the traveled way, operate all traffic control devices on the vehicles and station flaggers and vehicles to protect the worksite and the traveling public while maintaining two-way traffic.

614.13 Asphalt Concrete for Maintaining Traffic. The Contractor may use either a Type 1 or Type 2 mix of Item 441 asphalt concrete PG 64-22, or an asphalt concrete surface course the Engineer approves.

Where materials are placed in small quantities or under adverse conditions, the Engineer may waive specification requirements for placing and finishing if, in the judgment of the Engineer, it is determined that the Contractor can obtain satisfactory results in providing a smooth and durable pavement surface.

This material is intended to be used to maintain pavement free from defects as described in 614.02.B.

614.14 Performance. If, in the opinion of the Engineer, the Contractor is not furnishing proper maintenance of traffic facilities and proper provisions for traffic control, the City may take the necessary steps to place them in proper condition, including hiring a third-party, and the City will deduct the cost of such services from any money that may be due or become due the Contractor.

Identify all pavement deficiencies within the work area. Repair deficiencies as soon as possible and within 24 hours from notice of the deficiency.

614.15 Method of Measurement. The City will measure Work Zone Marking Signs as the number of sign installations, including the sign, necessary supports, and all attachment hardware. The City will include all other work zone signs under Maintaining Traffic unless separately itemized.

The City will measure Work Zone Pavement Markings complete in place, by class and material, in the units designated. Line quantities will be the length of the completed stripe, including gaps, intersections and other sections of pavement not normally marked. Work Zone Pavement Markings will include the layout, application and removal of the markings, when required.

The City will measure Sign Day for Portable Changeable Message Signs by the number of days each sign is at the Project. Measurement will begin when each unit is in active service and will continue until the Engineer determines the Portable Changeable Message Sign is no longer needed. A Sign Day will be deducted if a PCMS is not working properly for more than 4 hours in one sign day or if the Contractor removes the PCMS from the Project without the Engineer's determination that it is no longer needed for the Project.

614.16 Basis of Payment. The City will make partial payments according to 109.09.

Unless separately itemized, the lump sum price bid for Maintaining Traffic shall include the cost of removal or covering of conflicting pavement markings, layout, application and removal of pavement markings when required, maintaining the existing roadway in a safe condition for public use, removing abrasive and salt residue remaining from snow and ice control performed by Local Governments, providing flaggers and their equipment, and furnishing, maintaining in an acceptable condition, and subsequently removing the following work zone traffic control items as required by the Contract Documents:

A. Signs, supports, flags and warning lights.

B. Drums, cones, gates, barricades, and vertical panels.

C. Arrow boards.

D. Work zone traffic signals.

E. Lighting for work zone signals, law enforcement officers, and flaggers.

The lump sum price bid for Detour Signing includes the cost of the Contractor furnishing, installing, maintaining, and removing the detour signing as shown on the plans, or as directed by the Engineer, and their necessary supports.

The City will pay for the following items under their associated item numbers: 502 Structure for Maintaining Traffic, 615 Roads and Pavement, 622 Concrete Barrier. The City will pay for aggregate and calcium chloride authorized by the Engineer and used for Maintaining Traffic under Item 410 and 616.

The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
614	Lump Sum	Maintaining Traffic
614	Lump Sum	Detour Signing
614	Each	Replacement Drum
614	Each	Replacement Sign
614	Each	Object Marker, ___ - Way
614	Each, Mile, Foot	Work Zone Pavement Markings
614	Each	Work Zone Raised Pavement Marker
614	Sign Day	Portable Changeable Message Sign
614	Each	Work Zone Speed Limit Sign
614	Each	Work Zone Marking Sign
614	Hour	Law Enforcement Officer without Patrol Car
614	Hour	Law Enforcement Officer with Patrol Car
614	Each	Barrier Reflector
614	Each	Work Zone Crossover Lighting System
614	Each	Work Zone Impact Attenuator
614	Mile	Work Zone Lane Line, Class ___, ___*
614	Mile	Work Zone Center Line, Class ___, ___*
614	Foot	Work Zone Channelizing Line, Class I, ___*
614	Mile	Work Zone Edgeline, Class I, ___*
614	Foot	Work Zone Gore Marking, Class II, ___*
614	Foot	Work Zone Stop Line, Class I, ___*
614	Foot	Work Zone Arrow, Class I, ___*
614	Foot	Work Zone Crosswalk Line, Class I, ___*
614	Foot	Work Zone Dotted Line, Class I, ___*
614	Cubic Yard	Asphalt Concrete for Maintaining Traffic

* Type material (642 paint; 740.06, Type I or Type II 740.10; or left blank to allow any of the four.)

ITEM 615 ROADS AND PAVEMENTS FOR MAINTAINING TRAFFIC

615.01 Description
615.02 Fences
615.03 Earthwork
615.04 Guardrail
615.05 Pavement
615.06 Sidewalk
615.07 Maintenance
615.08 Removal
615.10 Method of Measurement
615.11 Basis of Payment

615.01 Description. This work consists of providing, maintaining, and subsequently removing roads appurtenances, and pavements for maintaining traffic. When the Proposal does not include a pay item for temporary roads as set forth in this item, perform such work under Item 614.

615.02 Fences. If necessary, replace permanent fencing with temporary fencing while occupying any temporary Right-of-Way, and provide, erect, and maintain comparable temporary fencing during the period of construction. Take ownership of the existing fence. The Contractor may use this material in the erection of the temporary fence. Before occupancy of the temporary Right-of-Way is terminated and before removal of the temporary fence, the Engineer will notify the property owner to reinstall permanent fencing according to the Right-of-Way settlement; provide Engineer with adequate notification.

615.03 Earthwork. Excavate and construct embankment necessary for providing and maintaining temporary roads and any associated drainage facilities, as well as subsequent removal of temporary roads and restoration of the areas to their original condition, according to Item 203. Construct adequate side ditches in cut sections, and provide drainage pipe and culverts where necessary. Ensure the side slopes are not steeper than 1.5:1, unless otherwise shown on the plans.

615.04 Guardrail. Where the height of the embankment is 5 feet or more, measured at the outside edge of the paved surface, and the side slope is steeper than 4:1, provide guardrail at a distance of at least 1.5 feet from the edge of the required width of the surface course. Conform to one of the types of guardrail specified in Item 606, except that the City will allow the Contractor to re-use material in good condition.

615.05 Pavement. Ensure that the pavement surface is constructed to the width shown in the plans, of the materials, and in the manner specified.

Prepare the subgrade according to 204.03 and 204.04.

Compact the subgrade according to 204.03. Identify and replace soft subgrade according to 204.04.

Where Class A or Class B pavement is shown on the plans, provide either rigid pavement or flexible pavement conforming to the following minimum requirements:

MINIMUM COURSE THICKNESS REQUIRED

Pavement Type	Course Make-Up	Class A	Class B
Rigid [7]	452	9 in	7 in
Flexible [6]	441 Type 1 [1]	1-1/4 in	1-1/4 in
	441 Type 2 [2] [5]	1-3/4 in	1-3/4 in
	302 [3] [5]	5-1/2 in	4 in
	304 [4] [5]	6 in	6 in

[1] Meet surface course requirements.
[2] Meet intermediate course requirements.
[3] The Contractor may use 301 or 441 Type 2 intermediate course.
[4] The Contractor may use 2-1/2 inches 301, 302, or 441 Type 2 intermediate course in lieu of 6 inches of 304.
[5] The Engineer may waive maximum placement lift thicknesses if quality control testing conforming to City Supplement 1055 is performed and a final density between 93 and 96.5 percent is achieved.
[6] The Contractor may use 442 in lieu of 441.
[7] The Contractor may use 307 in lieu of 452.

For the indicated pavement type and courses, conform to the requirements of the specified items except as modified below.

For rigid pavements, conform to Item 452. Tiebars or hook bolts for longitudinal joints are not required. Use dowels only at transverse expansion and construction joints. Conform to the quality requirements set forth in 499.02 for the materials, except the requirements of 703.13. Use Class COC 1 concrete. For any part of the 452 pavement that is to be incorporated into the permanent pavement, the above exclusions do not apply and conformance to Items 452 and 499 is required.

For a 441 course, if the Contractor spreads and finishes the materials by acceptable hand methods, the City will waive the requirements for smoothness.

Use a PG 64-22 asphalt binder for temporary asphalt pavement. If any part of the temporary pavement will be incorporated into the project permanently, then use the contract-specified PG asphalt binder grade for the pavement course.

For a 304 course, if the Contractor spreads the aggregate by approved hand methods, the City will not require side forms. If the 304 course is to be removed, the Contractor may use reclaimed asphalt concrete or Portland cement concrete pavement.

Determine the thickness of the courses by field measurement.

Maintain the temporary pavement in a condition suitable to the Engineer until such time as the permanent pavement is constructed. If the temporary pavement is not maintained in a condition acceptable to the Engineer, the City may take any necessary action to have the temporary pavement placed in a proper condition, and the cost of any such actions by the City shall be deducted from payments which may be due or may come due the Contractor.

615.06 Sidewalk. If temporary walks are required, provide the type of walk shown in the plans in accordance with Item 608, except Item 608.05 crushed aggregate walks is not permitted.

615.07 Maintenance. Maintain all portions of the temporary facilities in good condition with respect to both safety and smoothness for travel as long as it is needed for maintenance of traffic. If the Engineer determines that the Contractor is not properly maintaining the temporary facilities, the City may put them into proper condition according to 105.15.

615.08 Removal. If the temporary facilities are no longer needed, remove them, except such portions of the embankment as are shown on the plans to be a part of the new roadway embankment, and leave the area in a neat condition.

Take ownership of all material removed, unless otherwise shown on the plans. Use all suitable material in the work or legally use, recycle, or dispose according to 105.16 and 105.19.

615.10 Method of Measurement. The City will measure the quantity of Pavement for Maintaining Traffic by the number of square yards of pavement surface placed, maintained, and removed as directed, measured complete in place.

The City will measure Temporary Pavement furnished and placed under this item as the actual area placed, but in no case will the limiting lines for measurement be in excess of 1 foot exterior to the excavation limits shown on standard drawings, unless otherwise approved by the Engineer.

The City will measure areas of soft subgrade, undercut and replaced, according to 204.08.

615.11 Basis of Payment. Payment for Roads for Maintaining Traffic includes the installation, maintenance, and removal of all fencing, earthwork, guardrail, sidewalk, and all other items as necessary to provide a complete, functional, and safe installation for public use.

The City will pay for areas requiring undercut and replacement conforming to 204.04 according to 204.09.

The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
615	Square Yard	Pavement for Maintaining Traffic, Class A
615	Square Yard	Pavement for Maintaining Traffic, Class B
615	Lump Sum	Roads for Maintaining Traffic
615	Square Yard	Temporary Pavement

ITEM 616 DUST CONTROL

616.01 Description
616.02 Construction Requirements
616.03 Method of Measurement
616.04 Basis of Payment

616.01 Description. This work consists of applying water or dust palliative for the alleviation or prevention of dust nuisance originating from earthwork construction operations from within the project construction limits.

616.02 Construction Requirements. Perform dust control operations at the time and location and in the amount ordered by the Engineer. Maintain control of the application of water or dust palliative at all times to minimize dust but not to create saturated soil conditions. The Engineer will determine whether water or dust palliative is to be used to alleviate or prevent dust nuisance, and the amounts of each material to be used. Do not apply calcium chloride to areas that will be subsequently seeded or sodded.

Furnish and apply water used for dust control by means of tanks equipped with suitable sprinkling devices.

Use dust palliative consisting of 712.02 calcium chloride or a brine solution containing a minimum of 30 percent by weight of calcium chloride. Spread the calcium chloride uniformly over the surface.

616.03 Method of Measurement. The City will measure Water by the number of M gallons (1000 gallon units) applied and measured either in tanks, tank wagons, or trucks of predetermined capacity; or by means of meters of a type and furnished and installed by the Contractor at no expense to the City; or determined by weight conversion.

The City will measure Calcium Chloride by the number of tons by weight measurement, furnished and applied. When brine is used, the City will determine the weight of calcium chloride by multiplying the number of gallons by the factor 0.0024.

616.04 Basis of Payment. The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
616	M Gallons	Water
616	Ton	Calcium Chloride

ITEM 617 RECONDITIONING SHOULDERS

617.01 Description
617.02 Materials
617.03 Prosecution
617.04 Shoulder Preparation
617.05 Furnishing and Compacting Additional Aggregate
617.06 Method of Measurement
617.07 Basis of Payment

617.01 Description. This work consists of preparing the shoulder, and furnishing and compacting additional aggregate on the existing or prepared shoulder.

Use removed or excavated materials in the Work when the material conforms to the specifications; if not, then recycle or dispose of the material according to 105.16 and 105.17.

617.02 Materials. Furnish materials conforming to 703.18.

617.03 Prosecution. If reconditioning shoulders as part of a resurfacing project and traffic is maintained, place shoulder material along with the paving operations as rapidly as possible. Complete all shoulder reconditioning within four days following the placement of the surface course or any course that results in a drop-off of 2.0 inches or greater.

617.04 Shoulder Preparation. Loosen the existing surface to a depth of 1 to 2 inches. If the surface is an asphalt mix or seal, cut the surface along the edge of the pavement with a blade or disc to give a straight vertical edge. Reduce pieces of loosened material that exceed approximately 1 1/2 inches in size to at least this maximum size or consider these pieces unsuitable material. Remove and dispose of oversized or other unsuitable material that would interfere with placing of aggregate. Reshape the loosened material as necessary to conform to the requirements for placing aggregate.

617.05 Furnishing and Compacting Additional Aggregate. Spread aggregate with approved spreaders. Do not dump or store aggregate on the pavement. Remove spilled aggregate from the pavement as spreading progresses.

Where the shoulder is relatively level, compact the material using crawler-type tractors, tamping rollers, trench rollers, suitable pneumatic tire rollers, or other suitable equipment. Use a minimum of four passes with compaction equipment weighing at least 6 tons. Perform the final compaction of the surface of the shoulder using a pneumatic tire roller. Where it would be unsafe to use the above compaction equipment due to the grade or width of the shoulder, use a side-mounted roller or side-mounted vibrating plate compactor that is securely attached to a tractor or other construction equipment. The side-mounted roller or side-mounted vibrating plate compactor must be able to adequately compact the aggregate while the equipment to which it is mounted remains on the paved surface. Use a minimum of four passes with the side-mounted roller and two passes with the side-mounted vibrating plate compactor. Compact the aggregate immediately after the spreading operation to prevent the loss of contained moisture and displacement of the material. Finished shoulder grade shall not exceed finished pavement surface elevation and shall provide positive drainage from pavement surface.

Apply water as directed by the Engineer when required to aid compaction and to prevent segregation of the material.

617.06 Method of Measurement. The City will measure Shoulder Preparation by the number of square yards.

The City will measure Compacted Aggregate, by the number of cubic yards in place computed from the profile grade and typical sections.

The City will measure Water by the number of M gallons or 1000 gallon units according to 616.03.

If the plans provide for the use of aggregate in a variable width or depth course and the City cannot readily calculate the quantity from profile grade and typical sections, the City will measure the cubic yards by converting from weight using the following conversion factors:

TABLE 617.06-1

Material	Conversion Factor
Crushed stone	3800 lb/yd^3
Crushed gravel	3900 lb/yd^3
Crushed slag [1]	
less than 90 lb/ft^3	3600 lb/yd^3
90 to 100 lb/ft^3	4000 lb/yd^3
more than 100 lb/ft^3	4500 lb/yd^3
Recycled Portland Cement Concrete	3400 lb/yd^3
Recycled Asphalt Pavement	4000 lb/yd^3
[1] Based on average dry rodded weight of standard sizes of slag aggregates on record at the Laboratory. The conversion factors listed are the long gradation weights. These numbers are based on the dry rodded weights of No. 67, 57, or 8 gradation. The City will determine slag weights based on weights obtained from the original source.	

The City will classify salvaged or mixed materials according to the material that makes up the majority of the mixture.

The moistures of the delivered material will be less than 2 percent above saturated surface dry condition or the payment will be based on the dry densities and dry weights.

Furnish freight bills or certified weigh bills according to Item 109.

617.07 Basis of Payment. The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
617	Square Yard	Shoulder Preparation
617	Cubic Yard	Compacted Aggregate
617	M Gallons	Water

ITEM 619 FIELD OFFICE

619.01 Description
619.02 General
619.03 Method of Measurement
619.04 Basis of Payment

619.01 Description. This work consists of providing, maintaining, and subsequently removing a field office for the exclusive use of the City for the duration of the Contract at a location approved by the Engineer.

619.02 General. Furnish a completely functional field office of the type specified in the Contract within 30 days from the issuance of the NTP. The City will assess an administrative fee of $100/day for every day from 30 days from the issuance of the NTP that the field office is not functional in accordance with the Contract.

Furnish each field office with a means for maintaining a room temperature between 68 and 80 °F.

Furnish electric service for each field office.

Furnish potable hot and cold water for each field office.

Furnish neat, sanitary, enclosed toilet accommodations for each field office. Furnish associated lavatory and sanitary supplies. Furnish supplies to clean the office and means for waste disposal. In addition, for a Type C Field Office, provide a bi-monthly cleaning service.

For the type of field office specified, provide the items indicated in Table 619.02-1.

TABLE 619.02-1 FIELD OFFICE

Item	Type A	Type B	Type C
Minimum ceiling height, ft	7	7	7
Minimum floor space, ft^2	150	500	1000
Separate enclosed room, ft^2 (Part of specified floor space)	0	0	100
Telephone service & telephones [1]	2	2	2
Network Infrastructure Wiring [2]	1	1	1
Multi-Function copier that is setup for scanning, printing, faxing and copying. [3]	1, 11×17	1, 11×17	1, 11×17
Calculator with tape	1	1	1
Desk and chair set	1	3	5
Work table, 30 × 72-inch	1	2	3
4-drawer, legal size, lockable metal file cabinet	---	1	2
2-drawer, metal file cabinet	1	2	2
Portable fire extinguishers [4]	1	1	2
Plan rack [5]	1	1	2
All-weather parking spaces	8	16	20

[1] For each telephone specified, provide the telephone itself, all wiring necessary to connect the phone, computers, fax machine and multi-function copier to the phone company system, and a working separate phone number for each telephone. Connect one phone to a recorded answering device. For Types B and C, provide one speakerphone.

[2] The field office shall be provided with network infrastructure wiring, including a minimum of five CAT 5 outlets for a Type B or a minimum of seven CAT 5 outlets for a Type C field office. The City will make all arrangements for internet connectivity with the internet provider; however the field office must be made ready to receive any necessary wiring hardware.

[3] Submit technical specifications at the Pre-Construction Meeting for approval by the Engineer. Provide the machine with all necessary maintenance and paper supplies, copier supplies, and maintenance of copier.

Color Print/Copy/Scan
- Copy/Print Speed: 30 Pages per Minute (Letter), 15 Pages Per Minute (Legal), 15 Pages Per Minute (Ledger) or higher
- Duplex printing support
- Automatic document feeder with 50 sheet duplexing document feeder
- Copier Memory: 1 GB
- Installed HDD: 40 GB
- Data encryption and HDD Erase Support included with machine
- Internal Stapler Support
- Paper Capacity - 250 sheet × 2 trays, 50-sheet Bypass tray
- Network Interface: 10/100Base-TX, 1000Base-TX
- Analog Fax Support Included with machine
- Color Scanning with following requirements:
  - Up to Up to 600 × 600 dpi
  - Scan Area up to 11" × 17"
  - Scanning Protocol Support - TCP/IP, SMTP, SMB, FTP, POP3, NCP
  - File Scan Types Supported: Single Page TIFF, JPEG, PDF, Multi- Page TIFF, PDF, and OCR PDF
  - Scanning Support for Scan-to-Email, HDD, SMB (Folder), URL, and TWAIN
- Network protocol support for TCP/IP
- Client and Server Print Driver Support for PCL Print Drivers
- Server Operating System Support for Windows Server 2008 and Windows Server 2008 R2 (32 Bit/64 Bit)
- Client Print driver support for Windows XP/Windows 7 (Both PCL/(32 Bit and 64 Bit))
- Minimum print/copy resolution of 600 × 600 dpi
- Secure printing with password or pin from client to copier

[4] Type 2-A:10-B:C, 5-pound size

[5] Capable of handling the breakdown of 22 × 34-inch sized plans into ten sections.

With the Engineer's written approval, the Contractor may modify the requirements for the field office.

Maintain all utility services (e.g., electric, security, telephone, water) for the duration of the project.

619.03 Method of Measurement. The City will measure Field Office, Type ___ by the number of months the office is maintained. A partial month at the end of the project will be paid as a full month.

619.04 Basis of Payment. The City will pay for accepted quantities at the contract price as follows:

Item	Unit	Description
619	Month	Field Office, Type ___

ITEM 620 DELINEATORS

620.01 Description
620.02 Materials
620.03 Layout
620.04 Removal
620.05 Installation
620.06 Method of Measurement
620.07 Basis of Payment

620.01 Description. This work consists of furnishing and installing delineators, removing existing delineators for disposal, and restoring the surface where delineators are removed.

620.02 Materials. Furnish materials conforming to:

Reflectors 719.01
Posts, flexible 719.03
Bollard, break away..... 719.04
Steel hardware..... 730.08
Brackets..... 730.09
Stainless steel hardware 730.10
Aluminum sheet and plate..... 730.11
Aluminum hardware..... 730.17
Reflective sheeting 730.192, 730.193

Delineators consist of reflectors mounted on flexible posts or brackets. Reflectors are reflective sheeting adhered to either a flexible post or an aluminum plate. The colors of reflectors of each type are:

Type C	White
Type D	Yellow
Type E	Red

Delineator reflector and flexible post color shall match that of the nearest edge line.

620.03 Layout. Lay out all delineator locations to ensure their proper placement. The Engineer will approve the layout before installation is started.

620.04 Removal. Remove delineators, including reflectors, posts, brackets, and miscellaneous hardware. Take ownership of the delineator. Remove and dispose of concrete for delineator post embedment.

Restore surfaces where delineator posts or concrete for embedment are removed.

620.05 Installation. Install delineators facing traffic, except install red reflectors facing wrong-way traffic. Do not remove the protective paper covering the face of flexible post-mounted reflectors until after installation. Ensure that posts are not more than 1:50 out of plumb. If soil conditions may cause the post to be out of plumb, the Contractor may drive a pilot shaft before installation.

Install flexible posts using methods and equipment that conform to the post manufacturer's recommendations.

Install break away bollards as per City of Columbus Standard Drawing 2195. Removal of debris and overburden and restoration of surrounding area is incidental to the bollard.

620.06 Method of Measurement. The City will measure Delineator by the number, including reflectors, supports and hardware, in place, completed and accepted.

The City will measure Removal of Delineator, by the number.

The City will measure Break Away Bollard by the number, in place, completed and accepted.

The City will measure the Removal of Bollard by the number, including all payment repair and soil restoration and seeding.

620.07 Basis of Payment. The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
620	Each	Delineator
620	Each	Removal of Delineator
620	Each	Break Away Bollard, Type ___
620	Each	Removal of Break Away Bollard

ITEM 621 RAISED PAVEMENT MARKERS (RPM)

621.01 Description
621.02 Materials

621.03 Layout
621.04 Installation RPM Casting
621.05 Installation RPM Retroreflector
621.06 Reflector Replacement
621.07 Reflector Color
621.08 Raised Pavement Markers Removed
621.09 Method of Measurement
621.10 Basis of Payment

621.01 Description. This work consists of preparing the pavement and furnishing and placing plowable raised pavement marker castings (RPMs) and prismatic retroreflectors, and removing existing RPMs for disposal.

621.02 Materials. Furnish materials conforming to:

Castings..... 721.01
Prismatic Retroreflectors and Adhesive 721.02
Casting adhesive..... 721.03

621.03 Layout. Before placing RPMs, lay out the location of all RPMs. Locate RPMs within 5 percent of specified spacing. Do not place RPMs under the following conditions:

A. On pavement surfaces with cracking, spalling, or failure of underlying base material.

B. Within 1 foot of active signal detector loop wires. Exercise care to ensure that detector lead-in cables are not cut.

C. Over pavement markings except with the Engineer's approval.

D. Within a roundabout.

E. Within 3 feet of a bridge expansion joint.

F. All bridge decks.

G. Within an intersection of a driveway or public street.

H. Within crosswalks, school symbols or RxR markings.

I. On dotted lines (dotted lines are 2 feet or 3 feet long with 6 feet or 9 feet spacing).

J. Adjacent to curbs if white edge line exists.

If the initial location of a RPM is determined to violate one of the aforementioned conditions, relocate the affected RPM longitudinally. Relocate the RPM within a distance not exceeding 25 percent of the specified RPM spacing. If necessary to relocate the RPM to a distance greater than 10 percent of the specified RPM spacing, do not install the affected RPM.

Place RPMs along double yellow centerline in line or on line. RPMs installed along a channelizing line are to be placed no more than 1 inch from the edge of the painted line. Place the RPMs installed along a lane line or dashed yellow centerline between and in line with the dashes.

Install replacement RPMs within 3 feet longitudinally of the damaged or missing RPM.

621.04 Installation RPM Casting. Cut parallel slots with 1/16 to 1/8 inch clearance on each side for installing RPM castings.

When a casting is inserted in the cut without casting adhesive to test proper cut, at least 3 of the 4 leveling lugs/tabs must contact the pavement surface and all four keel-ends of castings must be below the pavement surface.

Center each casting lengthwise and to have 1/16 to 1/8 inch clearance between pavement cut and casting for casting adhesive to bond properly. Ensure that only the leveling lugs/tabs are in contact with the pavement surface after insertion of casting in pavement so that a minimum of 1/16 inch of casting adhesive is the bonding adhesive between the casting and pavement. Ensure that casting adhesive fills all voids.

Ensure that the pavement cut is completely dry and free of dust, dirt or any other material that will interfere with the adhesive bond to the casting and the pavement. Remove casting adhesive on the active reflector face immediately.

Install the RPM casting within 24 hours after cutting the slots into the pavement. On new pavement surfaces, the Contractor may begin RPM placement as soon as the pavement markings for that section are completed and dry.

Ensure that the RPM casting is free of dirt, dust, oil, grease, rust, moisture, or any foreign matter that impairs adhesion to the pavement.

Place RPMs when the pavement surface temperature and the ambient air temperature are at least 40 °F and the pavement is dry. Heat both parts of the RPM casting adhesive to 100 ± 10 °F during installation when either the pavement surface or ambient air temperature is between 40 and 50 °F.

Ambient Air Temperature	Minimum Period Protected from Traffic
°F	Minutes
100	15
90	20
80	25
70	30
60	35
50	45
40	60

Do not allow traffic on the RPMs until the adhesive has cured.

Use two component approved casting adhesive to fill the pavement cut to within approximately 3/8 inch of the top of the pavement cut. A minimum of 3 of the 4 leveling lugs/tabs must be in contact with the pavement surface and the casting adhesive should ooze out from under the casting from all sides filling all voids around the casting and be level with the pavement surface.

Mix the casting adhesive according to the manufacturer's recommendations. Complete the mixing operation and placing of the RPMs rapidly. Do not use any mixed batch that becomes so viscous that it cannot be readily extruded from under the RPM with light pressure.

621.05 Installation RPM Retroreflector. Attach the reflector to the casting before installation or after the adhesive in the pavement slots has cured.

Remove all dirt, dust, oil, grease, rust, moisture, parts of damaged reflectors, or any foreign matter that impairs adhesion of the reflector to the casting.

Peel the release liner from the back of the reflector with butyl pad. Apply a wide bead (approximately 3/8 inch) of reflector adhesive sufficient to squeeze out on all sides when pressure is applied to seat the reflector.

Apply approximately 100 pounds of pressure on the reflector or foot pressure for 1 to 3 seconds. Do not allow adhesive material on the reflective surface of the reflector. Any adhesive on the active reflector must be removed immediately.

Apply the reflector when the pavement surface temperature and the ambient air temperature are at least 35 °F and the casting surface is dry. Do not attach the reflector to the casting when rain over the work site is imminent.

621.06 Reflector Replacement. Replace damaged, non-retroreflective, or missing reflectors within the existing marker installations where the casting remains intact with the appropriate reflector type. The Engineer will determine the location of replacement reflectors.

Perform the cleaning and attachment procedure for replacing reflectors within existing RPM installations according to 621.05.

621.07 Reflector Color. Use the appropriate reflector color for the following applications:

A. Channelizing Lines. White/red two-way reflectors with white facing traffic.

B. Lane Lines. White one-way or white/red two-way reflectors as specified, with white facing traffic.

C. Edge Lines. One-way reflectors facing traffic matching the edge line color or two-way reflectors with the edge line color facing traffic and red in the opposite direction.

D. Center Lines. Yellow two-way reflectors.

621.08 Raised Pavement Markers Removed. As designated, remove existing raised pavement markers. On all projects where the pavement is not being replaced, fill all depressions caused by removing the castings with asphalt concrete by the end of the next workday. Remove all standing water from the hole before filling. Compact the asphalt concrete flush with the pavement. Take ownership of removed raised pavement markers. For projects that will replace the pavement surface, such as resurfacing projects, the Contractor shall not be required to fill voids left after raised pavement markers have been removed.

621.09 Method of Measurement. The City will measure RPMs by the number of each furnished, complete with reflectors, in place, and accepted.

The City will measure RPM, Reflectors by the number of each, complete in place, for use on existing RPM castings in the pavement, and accepted.

The City will measure Raised Pavement Markers Removed or Raised Pavement Marker Reflectors Removed by the number. Payment will include the cost of asphalt concrete, if required, to fill depressions caused by removal of the castings.

621.10 Basis of Payment. The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
621	Each	Raised Pavement Marker Installed
621	Each	Raised Pavement Marker Reflector Replacement
621	Each	Raised Pavement Marker Removed
621	Each	Raised Pavement Marker Reflector Removed

ITEM 622 CONCRETE BARRIER

622.01 Description
622.02 Materials
622.03 Placing Concrete
622.04 Portable Barrier
622.05 Joints
622.06 Finish
622.07 Curing
622.08 Method of Measurement
622.09 Basis of Payment

622.01 Description. This work consists of furnishing and placing portland cement concrete barrier on the accepted and prepared subgrade, subbase course, or existing pavement. This item also consists of furnishing, placing, maintaining, and removing portable barrier.

622.02 Materials. Furnish materials conforming to:

Concrete,
Class COC 1 * 499
Reinforcing steel and wire fabric 509.02
Forms 515.14
Preformed filler 705.03
Curing materials 705.05, 705.06,
..... or 705.07 Type 2
Precast concrete 706.13
Dowel bars ..... 709.01 thru 709.05
Steel..... 711.01

622.03 Placing Concrete. Construct concrete barrier by cast-in-place, precast, or slip-form methods. For slip-form construction, conform to 609.04.C.

622.04 Portable Barrier. Furnish individual portable concrete barrier sections not less than 10 feet long. Install barrier reflectors (triple stacked) and object markers using the alternating spacing delineation method as per ODOT MT-101.70. When required, barrier using glare screen shall be of the size shown and spaced in MT-101.70 standard delineation method. The Contractor may substitute or may be directed to use City approved proprietary portable barrier products. As directed by the Engineer, repair or replace barrier sections damaged during handling or by traffic including barrier attenuators, all barrier reflectors, object markers, glare shields and all hardware for the life of the project.

622.05 Joints. Construct joints for cast-in-place or slip-formed barrier of the type and dimensions and at the locations specified.

A. Contraction Joints. The Contractor may construct unsealed contraction joints by either sawing, using metal inserts inside the forms, using a grooving tool, or using full-width 3/4-inch thick preformed joint filler conforming to 705.03. Make joints that are sawed, tooled, or formed by inserts a minimum of 1/8 inch wide and 3 inches deep. Saw joints as soon as curing allows sawing to the required depth with minimal spalling of the concrete surface.

B. Expansion Joints. Use 3/4-inch preformed joint filler conforming to 705.03 to construct expansion joints at locations as shown in the plans.

C. Horizontal Construction Joints. If and as shown on the plans, the Contractor may place horizontal construction joints.

622.06 Finish. Immediately following removal of fixed forms or slip-form construction, check the surface of the barrier with a straightedge and correct all irregularities of more than 1/4 inch in 10 feet. Finish and make corrections to the barrier surface according to 511.18.

622.07 Curing. Cure concrete according to 511.14, Method B and the following additional requirements. Apply the curing compound using an approved mechanical sprayer equipped with a shield to protect the spray from wind. For small areas, the Engineer will allow the use of other acceptable methods.

Do not apply any load or conduct any work that will damage newly placed concrete. Allow a minimum of 36 hours of cure time to elapse on any concrete placed first at a horizontal construction joint. The Contractor may cure precast sections according to 515.15. With the Engineer's approval, the Contractor may also use radiant heated forms for curing.

The Contractor may use 511.14, Method A for curing of short sections of barrier (leave-outs); however, before the curing is completed for any leave-outs, apply material conforming to 705.07, Type 2 at the normal rate specified in 511.14, Method B.

The Contractor may cure horizontal construction joints between the foundation and the upper portion of the barrier, and between portions of the upper barrier placed separately according to 511.14, Method A or B. Do not remove the membrane before placing the next portion of the concrete barrier.

622.08 Method of Measurement. The City will measure Concrete Barrier by the number of feet along the centerline of the top of the barrier, including all transitions, and bridge pier sections as specified, complete in place excluding end anchorages and excluding end sections.

The City will measure Reinforced End Anchorages of the type specified by the number each complete in place.

The City will measure End Sections of the type specified by the number each complete in place.

The City will measure Portable Barrier and Portable Barrier, Bridge Mounted by the number of feet for each application of the barrier placed according to the plans. The City will measure each re-use of barrier sections at a different location required by the plans separately.

The City will not measure repaired or replacement barrier sections damaged during handling or by traffic.

622.09 Basis of Payment. The cost of all inserts, sleeves, fittings, connectors, reinforcement, dowels, preformed filler, excavation, aggregate base, and backfill is incidental to these items.

The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
622	Foot	Concrete Barrier, Type ___
622	Each	Concrete Barrier End Anchorage, Reinforced, Type ___
622	Each	Concrete Barrier End Section, Type ____
622	Foot	Portable Barrier, ___"
622	Foot	Portable Barrier, ___" Bridge Mounted

ITEM 623 CONSTRUCTION LAYOUT STAKES

623.01 Description
623.02 General
623.03 Basis of Payment

623.01 Description. This work consists of furnishing, placing, and preserving construction layout stakes or other controls in accordance with the Contract Documents for the construction of various elements of the Project, and removing all stakes at the completion of the Project. Reproduce and submit field notes of all layout work to the Engineer as the work progresses.

623.02 General. After award of the Contract, verify horizontal and vertical controls. Locate and reference the centerline of the project, locating the P.C. and P.T. of horizontal curves and sufficient points on tangent to provide a line of sight. The location and elevation of bench marks are noted on the plans. Provide field forces and set all necessary stakes for this project, including but not limited to stakes that are needed to establish offset stakes, reference points, slope stakes, pavement and curb line and grade, stakes for bridges, culverts, sewers, waterlines, drainage structures, paved gutters, walls, monuments, fence, right-of-way lines, and any other horizontal or vertical controls, including supplementary benchmarks, necessary to secure a correct layout of the work. Set stakes for the line and grade of pavement and curb at sufficient station intervals but not exceeding 50 feet on tangents and not to exceed 25 feet on curves and points of super elevation to ensure conformance to plan line and grade.

The Contractor is responsible for having the finished Work conform to the lines, grades, elevations, and dimensions shown on the plans. All submitted cut sheets will provide both beginning and closing benchmark elevations and descriptions. Any inspection or checking of the Contractor's layout by the Engineer and the acceptance of all or any part of it does not relieve the Contractor of the responsibility to secure the proper dimensions, grades, and elevations of the several parts of the work. Exercise care in the preservation of stakes and benchmarks, and reset them at no additional cost to the City when any are damaged, lost, displaced, or removed. Use competent personnel and suitable equipment for the layout work required and provide that a Registered Professional Engineer or a Registered Surveyor supervises the operation.

The Contractor's field forces, under the direction of a Registered Professional Engineer or a Registered Surveyor shall verify plan elevations for proper fit to existing conditions and for plan intended drainage where proposed items meet existing items. Notify the Engineer of any discrepancies.

623.03 Basis of Payment. The City will pay equal monthly payments based on the life of the project, not to exceed the lump sum bid price.

Item	Unit	Description
623	Lump Sum	Construction Layout Stakes

ITEM 624 MOBILIZATION

624.01 Description
624.02 Limitation
624.03 Method of Measurement
624.04 Basis of Payment

624.01 Description. This work consists of the preparatory work and operations including, but not limited to, those necessary for the movement of personnel, equipment, supplies, and incidentals to the project site; for the establishment of all field offices, buildings, and other facilities necessary for work on the project; for all other work and operations that must be performed or costs incurred before beginning the Work on the other contract items; and for demobilization.

If Mobilization is not included as a pay item in the Contract, the City will not pay for this work separately but will consider it incidental to the other Contract Items.

624.02 Limitation. The City will limit the sum of the partial payments specified in 624.04.A and 624.04.B to the amounts shown in Table 624.02-1 under "Maximum Total of Partial Payments". The City will pay the balance of the lump sum amount bid, as specified in 624.04.C.

TABLE 624.02-1

Total Contract Amount		Maximum Total of Partial Payments
More than	**Up to, inclusive**	
($)	($)	($)
0	50,000	0
50,000	100,000	2,000
100,000	200,000	4,000
200,000	500,000	10,000
500,000	1,000,000	20,000
1,000,000	2,000,000	40,000
2,000,000	5,000,000	100,000
5,000,000	10,000,000	200,000
10,000,000	20,000,000	400,000
20,000,000	40,000,000	800,000
40,000,000	60,000,000	1,200,000
60,000,000	80,000,000	1,600,000
80,000,000	--	2,000,000

If the lump sum amount bid for Mobilization exceeds the total shown in Table 624.02-1 for partial payments, the City will pay the excess upon completion of the Project.

624.03 Method of Measurement. The City will measure Mobilization as a unit, acceptably performed.

624.04 Basis of Payment. The City will make partial payments according to 109.07 and as modified by the following schedule:

A. The City will release 50 percent of the lump sum amount bid for Mobilization or 50 percent of the amount shown in 624.02, whichever is less, to the Contractor with the first payment estimate, but not sooner than 15 days after the start of work at the project site.

B. The City will release an additional 40 percent of the lump sum amount bid for Mobilization or 40 percent of the amount shown in 624.02, whichever is less, with the first regular estimate after 10 percent of the original total contract amount, including payments for delivered materials but excluding Mobilization, is earned.

C. Upon completion of all work on the project, including final cleanup, the City will release payment of the remaining 10 percent of the lump sum amount bid for Mobilization and any amount of the lump sum price bid for Mobilization, in excess of the total amount shown in 624.02 for partial payment. Final cleanup includes but is not limited to the removal of construction layout stakes installed under Item 623 and as directed by the Engineer, sediment and erosion control items installed under Item 207.

The City will pay for accepted quantities at the contract price as follows:

Item	Unit	Description
624	Lump Sum	Mobilization

ITEM 625 TRAFFIC SIGNAL UNDERGROUOND

625.01 Description
625.02 Definitions
625.03 Codes
625.04 Permits
625.05 Materials
625.06 Shop Drawings
625.07 Incidentals
625.08 Luminaires
625.09 Luminaire Supports
625.10 Foundations
625.11 Junction Boxes (Handholes) & Pull Boxes (Manholes)
625.12 Raceways and Conduits
625.13 Trenching
625.14 Jacking or Boring
625.15 Power Service (Control Equipment)
625.16 Grounding
625.17 Wiring and Cabling
625.18 Connections
625.19 Testing of Installations
625.20 Plastic Caution Tape

625.21 **Removal of Lighting Equipment**
625.22 **Method of Measurement**
625.23 **Basis of Payment**

625.01 Description. This work consists of furnishing and installing highway lighting equipment complete and ready for service. This work shall also include necessary excavation and backfill, disposal of discarded materials, restoration of disturbed facilities and surfaces, and testing as specified.

625.02 Definitions. Lighting terminology herein is defined in the American National Standard Practice for Roadway Lighting.

625.03 Codes. Follow the National Electrical Code, as adopted by the State of Ohio, the National Electrical Safety Code and local codes where applicable.

625.04 Permits. Obtain all permits required as an incidental to the construction of the lighting installation.

625.05 Materials. Furnish materials conforming to:

Concrete Class COC 6	499, 511
Reinforcing steel	509.02
Sand	703.06
Cable	725.02
Conduit	725.04, 725.051, 725.052
Pull boxes	725.06, 725.08, 725.12
Junction boxes	725.10
Luminaires	725.11
Lamps	725.11
Cable connectors and connector kits	725.15
Cable splicing kits	725.15
Ground rods	725.16
Multiple cell conduit	725.20
Anchor bolts and nuts	725.21
Light poles	725.21
Light towers	725.21
Portable power units	725.21
Plastic caution tape	725.22

625.06 Shop Drawings. Submit, to the Engineer prior to incorporation, two copies of the shop drawings and catalog cuts that identify and describe each manufactured item that is being incorporated into the construction. Certify in writing that each manufactured item is in conformance with all contract requirements for that item. Ensure that the documents describing each item indicate the project number (including the construction year), the bid reference number, and the item number and description under which the item is being installed. Also ensure that the documentation contains all of the information needed to allow the Engineer to determine that the item to be supplied meets all applicable requirements along with all of the information needed by the maintaining agency to obtain an identical replacement unit from the manufacturer. When a given item is to be incorporated into the construction under multiple bid item reference numbers, pay item numbers and descriptions, furnish a separate and complete documentation package for each bid item reference number, pay item number and description under which the item is to be installed. When multiple items are to be incorporated under a single bid reference number, pay item number and description, submit the documentation for all such items together.

625.07 Incidentals. Furnish and install all incidentals necessary to provide a complete and practical working unit or system.

625.08 Luminaires. A luminaire consists of a housing with a lamp, a lamp socket, the optical components to direct the output from that lamp, and the electrical components needed to operate the lamp.

Ensure that luminaires of the same type (i.e. high mast, low mast, conventional, underpass, post top, etc) in a given installation (i.e. interchange, rest area, weigh station, etc.) are of the same brand.

Align each luminaire vertically and horizontally to the roadway as specified. Where the profile grade exceeds 4 percent and the luminaire is mounted less than 60 feet above the roadway, adjust the luminaire to be perpendicular to the roadway rather than gravimetric level.

At the locations designated in the plans or as directed by the Engineer, furnish and install glare shields obtained from the manufacturer of the luminaire.

Apply a clearly-visible, liberal coating of metal-free molybdenum disulfide and graphite-based anti-seize compound to all fasteners used in accessing the lamp for replacement.

After all other work has been completed, clean the reflector, refractor and other components of the optical assembly just prior to leaving the job.

625.09 Luminaire Supports. Luminaire supports fall into three categories: bracket, light pole, light tower.

A bracket is the attaching hardware used to mount a luminaire onto the face of a wall or pier cap, or hang a luminaire from the bottom of a deck or beam or other similar installation. A bracket is often supplied for the luminaire by the luminaire manufacturer to facilitate the installation of the luminaire. A more complex situation will require extensive work to fabricate a bracket for the situation.

A light pole is the pole with one or more fixed brackets or arms for supporting luminaires above the roadway to be lighted. A light pole also includes a lower portion of the pole which is embedded or a mounting plate, any base for housing components or wiring, and when specified a breakaway device such as a frangible base, frangible couplings or slip plates.

A light tower is a shaft with a base plate, head frame, ring or similar structure on which one or more luminaires are mounted with a mechanism for lowering the mounting ring and luminaires for servicing and a lightning protection system.

Ensure that luminaire supports of the same type (i.e. high mast, low mast, conventional, underpass, post top, etc.) in a given installation (i.e. interchange, rest area, weigh station, etc.) are of the same brand.

Plumb each light pole and each light tower. When shims are used, use only shims of an approved design and installed in an approved manner. Do not install more than the minimum number needed to plumb the pole and neither exceed the maximum allowed total thickness of the shim pack nor the maximum number of shims permitted. When leveling nuts are used, ensure that such nuts are installed in approved locations and that both the anchor and the leveling nuts are properly tightened according to AASHTO LTS-6 (*Specifications for Structural Supports for Highway Signs, Luminaires, and Traffic Signals,* 2013) section C5.17.5.2.

Ensure that the grounding connections for each light pole or light tower have been made and that the resultant ground is within the earth resistance limit specified.

Apply a suitable lubricant to prevent seizing to each cover fastener and install all such fasteners.

After erection, the Engineer will inspect each pole for defects in the surfaces and determine for each defect discovered whether the defect is minor enough that the Contractor may be allowed to field repair the finish or major enough that the Contractor must replace the pole. Make finish repairs and provide and install replacement poles as directed by the Engineer for no additional charge to the project.

Label each light pole and light tower with the alpha numeric identifier. Place the identifier on the quadrant of the surface of the pole that faces oncoming traffic at approximately 7 feet above the roadway surface. Apply the identifier letters and numerals when the ambient air temperature, the temperature of the labeling material and the temperature of the surface to which the labels are applied are all above 40° F. Consider as incidental work the identification of the light poles or light towers and the removal of any previous such identifier in the case of light poles or light towers being reassigned.

625.10 Foundations. Excavate for each foundation to the dimensions given.

If a cave in should occur during excavation, the Contractor may continue excavating using casing, sleeving or other methods with the approval of the Engineer.

Where, in the opinion of the Engineer, the excavation for a foundation has revealed an unstable condition at the bottom of the excavation, drill the foundation shaft deeper, enlarge the diameter of the drilled shaft, or make other modification to the foundation as directed by the Engineer who shall initiate the appropriate arrangements to compensate the Contractor for the addition work required.

When rock is encountered, continue excavation to a minimum of 3 feet into rock. The Engineer may then decrease the total depth of the foundation to not less than 6 feet for a light pole or 10 feet for a light tower.

Reinforce each foundation with steel as specified and place such steel reinforcing according to Item 509.

Install the anchor bolts for the light pole or light tower in each foundation using anchor bolt setting templates.

Place Class COC 6 concrete for the foundation according to Item 511 except that forms will not be required for portions of foundations extending more than 6 inches below the ground line, unless the soil does not have sufficient stability to stay in place during the placing of the concrete.

Finish the top of each foundation smooth and level.

After forms have been removed, backfill the excavated spaces around each foundation with suitable material placed and tamped in thin layers as directed by the Engineer.

625.11 Junctions Boxes (Handholes) & Pull Boxes (Manholes). Furnish and install a junction box of the size and type specified. Furnish each junction box embedded in concrete with a drain. Lubricate each cover screw with a compound to prevent the screw from seizing and install all cover screws.

Furnish and install a pull box of the size and type specified. Excavate for each pull box as nearly as practicable to the outside dimensions of the pull box. Install a 6 inch gravel base with a 4 inch underdrain to a suitable outlet below each pull box. After setting the pull box to proper grade, backfill the excavated spaces around the pull box with suitable material placed and thoroughly tamped in thin layers.

When a pull box is to be installed in a paved area, remove an adequate area of the paving by saw cutting the sides of the area to be removed, or by removal of the paving back to an expansion joint as instructed by the Engineer. After setting the pull box to proper grade, backfill the excavated spaces around the pull box with suitable material placed and thoroughly tamped in thin layers, and restore the pavement base and paving to match the surround.

The Contractor may use conduit ells to bring the conduit up into the housing. Extensions, if available, may be used to eliminate the need for conduit ells.

Bond metal pull box lids by attaching the equipment grounding conductor to the frame diagonal.

625.12 Raceways and Conduits. Furnish and install conduit of the sizes and types specified. When the location, type or size of a conduit has not been indicated, submit to the Engineer working drawings showing the location and size and type of each such conduit along with the number

and size of wires contained in each such conduit and secure the approval of the Engineer prior to installing the conduit. Use of conduit material shall comply with the NEC.

When not otherwise specified, all conduit and fittings on an individual run of conduit shall be of the same material except for approved manufactured transition fittings required at end of the run when the item into which the conduit terminates is not of the same material as the conduit. HDPE conduit shall not be used where exposed, or within buildings.

Install each conduit with a minimum amount of bending and ensure that the total bending between adjacent access points (junction boxes, pull boxes, light poles, control equipment enclosures, etc.) does not exceed 270 degrees. Do not bend any conduit to a bend radius of less than 12 times the internal diameter of the conduit. Bend each conduit in such a manner as to avoid damage to the conduit and any protective coating and such that the internal diameter of the conduit will not be reduced.

Remove the rough edges from the cut end of each conduit. In addition, ream the cut end of each metallic conduit. Bush each end of each conduit to further protect the wire insulation and cable jackets from damage.

Where threads have been cut onto ferrous metallic conduit after galvanizing, paint the threaded area with a UL-Listed anti-corrosion compound in such a manner that there will be no unprotected surfaces.

Make each conduit joint tight to provide structural integrity in all conduits and to electrically bond the jointed sections of metallic conduit. Provide an equipment grounding conductor that is not in a jacketed cable assembly in metallic conduits when not otherwise available and bond the conduit to this grounding conductor.

Securely fasten onto or build into the structure each conduit.

Install the appropriate expansion or deflection joint in each conduit at all locations where movement must be accommodated (such as expansion joints on structures) and install suitable bonding to ensure electrical continuity of the grounding system.

Bond all metallic items enclosing electrical conductors together and to good earth ground.

Furnish each enclosure, junction box, pull box and conduit with a drain. When the low point of a conduit does not occur at a drained access point, install a T coupling at the low point of the run and route the side outlet to drain.

Where underground conduits are to be encased in concrete, use Class COC 6 concrete and furnish a minimum of 3 inches of concrete on all sides using spacers.

After installation of the conduit and prior to installing the cables, run a mandrel whose diameter is at least 90% of the interior diameter of the conduit through the conduit.

Install non-organic fiberglass pull tape with a minimum 1800 ft./lbs tension strength in each new conduit, regardless of the presence of cable in the conduit.

If a single new conduit has no electrical cable, install a tracer wire in the conduit and cap the ends. For multiple new conduits installed in the same trench, other than interconnect conduit bank, install a tracer wire in one of the conduits and cap the ends if none of the conduits have electrical cable. The tracer wire shall be a number 10 gauge, stranded copper, polyester or cross-linked polyethylene (XLPE) insulated wire. The tracer wire insulation shall be resistant to moisture absorption and abrasive actions. The jacket of the tracer wire shall be orange. The tracer wire shall be continuously run between pullboxes, poles, and cabinets and shall not be spliced except within a pullbox. The wire shall be tagged as “tracer wire”, coiled (3 feet in length) and left disconnected at each end (open circuit). Temporarily seal the ends of a conduit immediately after placement of conduit when the conductors or cable cannot be installed promptly.

All empty conduits shall be capped and the caps secured to the conduit with tape. Any conduit that exits a pull box, contains cable and directly enters an electronics cabinet, shall be sealed with polymer-based, mineral-filled reusable non-drying elastic duct sealing putty.. Do not use expanding foams or foam of any kind.

625.13 Trenching. Follow the routing shown on the plan. Keep the trench within 6 inches of the designated line where the trench is adjacent to and parallel with a curb or pavement.

In unpaved areas, the Contractor may use a plow in lieu of trenching with the approval of the Engineer. Use a machine that can install the duct uniformly at the specified depth without stretching or abrading the duct and which leaves a narrow self-closing slit which presents no significant hazard during the self-closing period.

In unpaved areas, make the trench a minimum of 2 feet deep and not more than 12 inches in width. Backfill the trench in layers not more than 4 inches in loose depth and compact each layer with a mechanical tamper or other approved method as directed by the Engineer. Use suitable soil to backfill a trench in earth. Use granular material to backfill a trench in an aggregate or in chemically stabilized subgrade. Ensure that the backfill material around and in the first 4 inches above the top of unit type duct cable not encased in concrete is sand or earth with no stones larger than 1/2 inch.

In paved areas, either make a slit or T type trench. Cut the pavement along existing joints or grooves where possible. Mark the pavement with cut lines and secure the Engineer’s approval of the location of the cut before cutting the pavement.

625.14 Jacking or Boring. In addition to the requirements of 625.12 to furnish and install conduit, use jacking or horizontal boring when the plan calls for such methods to be used. Use these methods in lieu of trenching only with the approval of the Engineer.

Jack only rigid galvanized steel conduit. Use only a machine designed for jacking conduit not the bucket or blade of a machine designed for earthwork.

Horizontal boring may be used to install any conduit or duct which has the adequate strength, flexibility and joints to withstand the process. Make the diameter of the bore no more than 5 percent larger than the outside diameter of the conduit or duct being installed.

625.15 Power Service. Furnish and install all equipment necessary to provide a complete electrical service to the roadway lighting facilities. Follow the National Electrical Code (NEC) Article 400 for enclosures, in the construction of all enclosures for power service and lighting control centers.

The power service equipment includes, but is not necessarily limited to: poles or other support structure for the mounting of the equipment, hardware for dead ending an overhead service drop or trench and conduit for receiving an underground service line, NEC Article 285 Type 1 (Surge Arrestor) surge protector device (SPD), meter base, customer service disconnect, magnetically held lighting contactor, photoelectric cell and Hand-Off-Automatic switch for control of contactor, overcurrent protection devices for each individual lighting circuit, enclosures, conduits, fittings, cables and connectors.

Assure all control equipment included in the power service is capable of operating within the provided enclosure(s) over appropriate temperature and humidity conditions. Assure that power service equipment that includes daytime lighting controls shall operate continuously with the enclosure placed in a location fully exposed to sunlight and daytime temperature of 100°F ambient.

Construct the lighting electrical system to provide selective coordination of overcurrent devices per NEC 240.12(1). Overload indications per NEC 240.12(2) are allowed but not required as part of a standard ODOT lighting control system. Provide to the Engineer:

A. Individual catalog sheets and device time-current curves and/or tables and

B. Combined graphical overlays that document acceptable installed overcurrent device coordination.

Provide this documentation for all installed overcurrent devices, including the service disconnect fuses, the lighting control center branch circuit breakers, and tower circuit breakers/ pole fuses (if present). Tabular data, if used, shall include the following time points as a minimum: 0.01, 0.02, 0.05, 0.1, 0.2, 0.5,1, 10, 100, and 300 seconds and additional points as needed to clearly show the overcurrent device operating characteristics. Include minimum melt time and maximum clearing time for fuses; include minimum and maximum clearing time for circuit breakers. Provide documentation of the utility-installed transformer ANSI fuse link type (e.g., K or T) and fuse rating (if available). Provide documentation of the utility-installed power service size (in kVA).

Provide to the Engineer a compiled list or catalog sheets showing the Short-Circuit Current Rating (SCCR) of all fuses and fuse holders, circuit breakers, switches and contactors, pursuant of the requirements in NEC Article 110.10.

If the power service has multiple enclosures, mark each enclosure in white letters engraved on a black plastic placard with the function of the equipment contained therein such as “SERVICE DISCONNECT”, “LIGHTING CONTACTOR”, “LIGHTING PANEL”, or other appropriate designation. Apply a durable, weatherproof adhesive arc and shock hazard warning label to the outside of each electrical enclosure that contains applicable voltage and/or arc hazard levels.

When an apparatus enclosure contains circuits above the 600 volt class, mark the enclosure in white letters on a red plastic placard with the warning “DANGER-HIGH VOLTAGE” on each enclosure door.

Install each photoelectric cell facing North unless the Engineer directs that a specific cell face otherwise to reduce interference from surround lighting.

Bond all metallic portions of the supporting structure, equipment housings and conduits properly and to an adequate earth ground.

Install a wood or plastic wire moldings from grade to 3 feet above grade over any grounding cables installed on a wood pole.

Coordinate and cooperate with the power company in the making of the connections to establish electrical service. Charges made by the power company for establishing of the account, extension of company facilities, connection of customer equipment to the power company facilities and energy will be borne by the maintaining agency.

625.16 Grounding. Connect each light pole or light tower to a local earth ground.

Connect each power service to a local earth ground.

Provide continuity of grounding by bonding the metallic portions of fixtures, apparatus enclosures, supports, conduits, raceways, junction boxes and pull boxes together and connecting to earth ground. At a light pole or a light tower, install a bonding cable between the grounding bushing on each metal conduit and the ground lug or bolt in the pole base. At a junction box or a pull box, install a grounding bushing on each metallic conduit not bonded to the box through the conduit connector, and install a bonding cable between the grounding bushings on the conduits and the ground lug or bolt in the box.

For a light pole, light tower, power service or other such item mounted independently, install one or more grounding electrodes.

For a luminaire, light pole, light tower, switch enclosure, or other such item mounted in or on major highway structures (i.e. bridges), connect the item to the structure grounding system.

For a lighting contactor, lighting circuit panel or other such item mounted in a building (i.e. motorists services building, weigh station scale house, etc.), connect the item to the grounding system provided for the building.

For each bridge, wall, or other structure having electrical elements contained therein or attached thereto, furnish all materials necessary including grounding electrodes and install a complete structure grounding system to bond all exposed metallic portions of the structure (i.e. beams, railings, etc.) electrically together and connect those items to good earth ground. In the case where structures are separate but adjacent, connect the multiple structures together to avoid any difference in earth potential between the structures.

Make the permanent connection between the each ground rod and the grounding conductor by exothermic welding.

If the earth resistance measurement exceeds 10 ohms for a ground for a traffic signal controller or a light tower or 25 ohms for any other ground, install a second/third ground rod at least 10 feet from the first and temporarily connect the second/third rod to the first. If the earth resistance still exceeds the above specified values, permanently connect the first two/three rods using the same type of cable used for the grounding conductor and continue to add rods one at a time as directed by the Engineer. Traffic signal controllers shall have a minimum of two ground rods.

Connect the rods with a ground wire jumper that is welded to each rod. Provide a separate pole ground rod and wire for all signal strain/support poles that have a pole mounted cabinet attached. The ground wire attached to the cabinet signal pole shall have a separate conduit and be on the opposite side of the foundation from the cabinet grounding system.

Qualified City Personnel will be present when any traffic signal installation ground rod reading is taken. For each testing device, maintain on site a calibration certificate from a certified, independent instrument calibration company and the operating instruction manual so City Technical Personnel can field verify the test procedure and results. Calibrate each device per its manufacturer's standards. Ensure that the certificate of calibration for each test device is dated within 6 months of the test. Do not conduct any testing if any test requirement is not met.

Where rock does not permit the driving of ground rods, develop an earth connection by constructing a grid from the partially driven rods supplemented by buried bare cable as directed by the Engineer.

625.17 Wiring and Cabling. Furnish and install electrical wires and cables of the types and sizes required with no in-line splices between terminations at devices unless specifically called for by the plan or directed by the Engineer.

Install wire mesh cable grips on vertical runs of wire or cable in poles and attach said grips to the "J" hook at the tops of the poles in such a manner as to prevent the weight of the vertical run from abrading the wire insulation or cable jacket where the wire or cable passes into or from the pole.

Identify all wires and cables, except bare ground bonding cables, as to circuit and function with tags or bands in the base of each light pole or light tower, each junction box or pull box, each apparatus cabinet, and other similar locations.

Pay out each wire, cable and duct cable by "unwinding" it from the shipping reel, spool or coils and not allow the wire cable or duct-cable to "spiral" from off the side of the spool reel or coil. In addition when wire cable or duct cable is being placed in trench, move the reel spool or coil along the side of the trench to allow the wire or cable to pay out into the trench as directly as practical. Seal the ends of each run of duct cable in the same manner as conduit as each run is installed.

Do not install duct cable when the temperature of the duct-cable cannot be kept above 32 °F except with the permission of the Engineer.

If the end of a wire or cable or duct must stand exposed to the elements or construction activities, protect said exposed end by enclosing it in a plastic bag or wrapping it with tape until the termination or connection can be made.

625.18 Connections. Make each wire and cable connection above grade (i.e. bases of light poles or light towers, junction boxes on structure or in concrete barrier medians, etc.) with an approved cable connector kit. Use quick disconnect type kits in the base of each light pole with a fused type in each line or phase conductor. Plug unused line side wire opening in each connector kit installed in the base of the light pole at the outer end of a circuit.

Make each cable connection below grade (i.e. pull boxes, junction boxes in retaining walls, etc.) with a cable splicing kit.

Protect partially assembled connections from damage and the elements.

625.19 Testing of Installations. Furnish equipment and personnel to perform each test as an incidental to the construction of the lighting installation. The Engineer will witness each test and judge the results.

A. Equipment Calibration. Submit to the Engineer the types, styles, or catalog numbers of all testing equipment to be used for such tests. Include a current Certificate of Calibration for each instrument showing that the instrument is in current calibration using standards traceable to The National Institute of Standards in accordance with the manufacturer's recommended process by a service center authorized by the manufacturer to calibrate the instrument. Certify and demonstrate to the satisfaction of the Engineer that the instrument has remained sealed since the calibration, and that the manufacturer's recommended process for ensuring that the instrument is in working order and producing valid results has been followed in conducting the test.

B. Grounding Electrodes and Grounding Systems. Furnish two certified copies of the completed test records to the Engineer on test reporting forms supplied to the Contractor by the Engineer or on alternate forms approved by the Engineer.

Measure the earth resistance in ohms of each ground immediately after it is installed and before the ground is attached to the item being grounded.

When the ground connection is by driven ground rods, measure each rod separately. In the event that a ground rod has a high resistance and additional rods are being added, measure the earth resistance of the combined group.

Measure a structure grounding system at each point where an exposed metallic item is to be connected to the system. Where driven ground rods are used as the electrodes of the structure grounding system, measure each ground rod separately prior to measuring the system.

Measure each ground grid at the each point where equipment is to be connected to the grid.

C. Circuit Continuity. Upon completion of each lighting circuit but prior to energizing the circuit, verify the continuity of each conductor of the lighting circuit from the power service to the load side socket in the line side of the quick disconnect connector kit in the base of each light pole and the line side of each disconnect switch at each light tower, lighted sign and underpass lighting system shall be verified. Demonstrate that there

is no cross connection between the conductor being tested and any other conductor (including conductors for other circuits) or earth ground. Conduct this test by applying a low test voltage between the conductor under test and one of the companion conductors for the same circuit and demonstrating that the test voltage is available between only those two conductors at the power service; the load side socket in the line side of the quick disconnect connector kit in base of each light pole; and the line side of each disconnect switch for a light tower, a lighted sign or an underpass lighting system and repeating the process until all possible pairs have been so checked. Throughout this test, ensure that each disconnect switch is in the open position and that the load side of each connector kit is unplugged. Temporarily disconnect the grounded neutral conductor from earth ground and check all pairings involving the neutral after which again connect the neutral to earth ground and check all pairings, both those involving the neutral and those that do not.

D. Cable Insulation. After the continuity of a conductor has been verified, test the insulation of that conductor and its connections. Ensure that each disconnect switch is in the open position and that the load side of each quick disconnect connector kit is unplugged during this test. Temporarily disconnect a grounded neutral conductor from earth ground when it is being tested. In addition, when a grounded neutral is under test and the circuit utilizes local equipment earthing rather than a continuous equipment grounding back to the power service, temporarily connect one of the companion line conductors to provide the equivalent of the continuous equipment grounding cable.

When the circuit conductor is comprised of both new wire or cable and wire or cable installed prior to the current project, test the insulation by the megohmmeter method and the resistance of the conductor under test to earth ground or any other conductor shall exceed 10 megohms.

When the circuit conductor is comprised of entirely new wire or cable, test the insulation by the high potential method in accordance with ODOT Supplement 1003.

E. Lowering Device Operation. Demonstrate to the Engineer that lowering devices on any luminaire supports so equipped operate properly by lowering and raising the luminaire assembly through the full range of motion of the device for each device on two separate occasions at least 10 days apart. The Engineer will record the dates of operation for each device and in case of failure the details of both the failure and the date and details of the correction. The Engineer will consider a particular unit satisfactory when the device has operated twice in succession on separate occasions without malfunction.

F. System Performance. Prior to acceptance and after all other tests are done, the completed lighting system shall be operated on electrical energy from the power company through the permanent customer service connection in its intended normal manner for ninety consecutive days. Notify the Engineer at least 3 days prior to the commencement of this performance test. In addition to the beginning and ending dates of the test period, the Engineer will record the date and details of each failure and the date and details of the repair. The Engineer will consider the performance satisfactory when the lighting installation has operated for ninety consecutive days without a failure due to the workmanship of the Contractor.

625.20 Plastic Caution Tape. Install tape approximately 6 to 10 inches below the final finished grade. Place with the printed side up and parallel with the finished surface. Ensure that the tape is not pulled, distorted or otherwise misplaced in completing the trench backfill.

625.21 Removal of Lighting Equipment.

A. Luminaire Removal. Remove the luminaire from its support taking care not to damage the luminaire, support or wiring connections. If the luminaire is to be reused within the same project, carefully store the luminaire on the project site. If the luminaire is to be reused, but not within the same project, carefully store the luminaire on the project site for pick up by the City owner. If the luminaire is not to be reused, properly dispose of the luminaire off the project site.

B. Luminaire Support Removal. Remove the luminaire support taking care not to damage the luminaire support, foundation or structure to which it is attached or wiring connections. If the luminaire support is to be reused within the same project, carefully store the luminaire support on the project site. If the luminaire support is to be reused, but not within the same project, carefully store the luminaire support on the project site for pick up by the City owner. If the luminaire support is not to be reused, properly dispose of the luminaire support off the project site.

C. Luminaire Support Foundation Removal. Remove the luminaire support foundation a minimum of one foot below finished grade or clear of proposed construction, backfill the resultant depression with compacted soil and restore the disturbed area.

D. Pull Box Removal. Remove the pull box, properly dispose of it off the project site, backfill the resultant depression and restore the disturbed area.

E. Disconnect Existing Circuit. Disconnect the portion of the lighting circuit to be removed or abandoned from the portion of the circuit to remain in service at the designated node point. Remove the cable from the link no longer to remain in service from the node point enclosure. Remove the conduit or duct for the link no longer in service from the node point enclosure and properly close the resultant openings in the enclosure unless the conduit or duct is to be left in place to allow another circuit link to enter the node enclosure.

F. Power Service Removal. Remove the existing power service equipment and properly dispose of the equipment off the project site. Equipment to be removed includes the wood pole or other supporting structure, foundation work pads, equipment enclosures, photoelectric cell and associated conduits, wiring, overhead or underground service lateral and all other appurtenances. Cut the cable enclosed in conduit which runs into the ground at the lower end of the bend to horizontal approximately 2 feet below grade. Backfill the resultant depression and restore the disturbed area.

Coordinate with the power company to ensure that the company disconnects the service and that items which belong to the power company that are removed, such as the meter base, are returned to the power company.

625.22 Method of Measurement. The City will include bracket arms with the light pole, light tower or combination support on which they are mounted for payment. However, when a bracket arm is to be mounted onto an existing support or a support provided by another aspect of the project, it may be a separate item for the purpose of payment in which case the City will pay for each bracket arm.

The City will include transformer bases with the light pole, light tower or combination support on which they are mounted for payment. However, when a transformer base is to be fitted to an existing light pole, it may be a separate item for the purpose of payment in which case the City will pay for each transformer base.

Furnish light pole anchor bolts with the light pole and include the setting of the anchor bolts with the foundation. However, in the case of a light pole mounted onto structures such as bridges and retaining walls where the bolts normally furnished with the light pole are not of the proper length and shape and/or the setting of the bolts must be done when the structure is constructed rather than being at the time of construction of the light pole foundation, the bolts shall be a separate item for payment in which case the City will pay for each bolt with the count being the number of bolt ends projecting for the anchoring of the light pole. The City will also make separate payment when the bolts are being set in a normal light pole or light tower foundation but the light pole or light tower is not being furnished by the Contractor or by others to the Contractor.

Foundations for light poles or light towers include excavation, dewatering, sleeving, casing, reinforcing steel, raceways, concrete, backfilling, and when required the 8 foot or 10 foot foundation section of concrete barrier, and the disposal of surplus excavation. For light poles or light towers mounted on median barrier or retaining walls, the junction box at the point where the stub conduit to the light pole or tower joins the main lighting circuit raceway and the stub conduit from the junction box to the light pole or light tower are also included. Anchor bolts, conduit ells and surface restoration not included elsewhere are also included with the foundation. Junction boxes include the drain.

Pull boxes include the aggregate for base.

Power service includes the control equipment, the support and foundations on which the equipment is mounted, the pull boxes with underdrain for gathering the lighting circuits into the control equipment at the power service location, ground rods and incidentals required for a completed power service. Also included are any poles, conduits, wire and cable to be provided by the owner to receive the incoming power from the power company.

Structure grounding system includes any ground rods or ground grids required as part of the system.

Ground grids include any ground rods required as part of the grid and includes the associated grounding conductor and connections from the resultant grid to the first point (or points) of connection. Ground grids that result from the addition of ground rods as a result of earth ground resistance measurements will be the sum of each ground rod installed such sum will also include all connecting cable and trenching.

A ground rod includes the associated grounding conductor and connections from the rod to the first point of connection.

The City will measure trench to the center of a light pole foundation, the center of a light tower foundation, the center of a pull box, the center of the pole of an embedded pole mounted power service, the center of the foundation for a power service with a foundation, or the wall of the building when the power service for the lighting in, on or within the building with no allowance for elevation change. The payment for trench includes all excavation, granular and other backfill material, compaction, disposal of surplus materials and restoration to match surrounding surface including any seeding, sodding or other plantings which were disturbed and the replacement of any minor items such as guardrail or fence panels, and return to former position and mounting of items such as trash containers, planter boxes or parking meters and small signs which were temporarily moved to facilitate the trenching. The payment for trench in paved areas includes the aforementioned and in addition sawing and removal of pavement, along with the repaving over the trench. For pavement, the City will separate trench in paved areas into Type A for pavements or sidewalks less than 6 inches thick and Type B for pavements 6 inches or greater.

The City will measure conduit to the center of a light pole foundation, the center of a light tower foundation, the center of a pull box, the center of the pole of an embedded pole mounted power service, the center of the foundation for a power service with a foundation, or the wall of the building when the power service for the lighting in, on or within the building with no allowance for elevation change. The payment for conduit includes couplings (plain, expansion, and alignment), bends, hubs, bushings, condulets and other such appurtenances but not junction boxes and pull boxes. The City will pay for conduit to be encased in concrete or installed by jacking or boring separately from conduit to be traditionally installed. Conduit will include concrete and other materials for encasement or the jacking or boring where specified.

The City will measure distribution cable to the center of foundation, pull box, junction box or power service, plus an allowance of 5 feet at each pull box and terminating points for slack and connections end except for a power service where the allowance will be 10 feet to allow for slack and connections with the sum multiplied by the number of conductors required.

The City will measure pole and bracket cable as the light pole support height plus the designated arm length with the sum multiplied by the number of conductors required. For twin arm poles the sum shall be increased by the length of the second arm plus the length of the first arm.

The City will measure duct cable to the center of foundation, pull box, junction box or power service, plus an allowance of 5 feet on each end except for a power service where the allowance will be 10 feet to allow for slack and connections with no multiplier for the number of conductors. Duct-cable includes the cable(s) and being a factory assembly is differentiated by the number and size of the conductors in each assembly.

The City will measure plastic caution tape to the center of a light pole foundation, the center of a light tower foundation, the center of a pull box, the center of the pole of an embedded pole mounted power service, the center of the foundation for a power service with a foundation, or the wall of the building when the power service for the lighting in, on or within the building with no allowance for elevation change.

625.23 Basis of Payment. The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
625	Each	Luminaire, (Functional Type), (Housing Size if Conventional), (Light Distribution), (Lamp Wattage), (Light Source), (Voltage)

625	Each	Glare Shield
625	Each	Light Pole, (Pole Style), (Design Number)
625	Each	Light Tower, (Design Number)
625	Each	Light Pole Anchor Bolts
625	Each	Light Pole Foundation
625	Each	Light Tower Foundation
625	Each	Junction Box, (Length × Height × Depth)
625	Each	Pull Box, (Material Type), (Length × Height ×Depth)
625	Foot	Conduit, (Material Type), (Nominal Diameter)
625	Foot	Trench
625	Foot	Trench in Paved Area, (Type)
625	Foot	Conduit Jacked or Drilled, (Material Type), (Nominal Diameter)
625	Each	Power Service
625	Each	Ground Rod
625	Each	Ground Grid
625	Each	Structure Grounding System
625	Foot	Pole and Bracket Cable, (Size of Conductors in AWG), (Voltage Rating)
625	Foot	Distribution Cable, (Size of Conductors in AWG), (Voltage Rating)
625	Foot	Duct Cable, (Duct Diameter) with (Number of Conductors), (Size of Conductors in AWG), (Voltage Rating) Conductors
625	Each	Connection
625	Each	Service to Underpass Lighting
625	Each	Portable Winch Drive Power Unit
625	Each	Luminaire Removed
625	Each	Luminaire Support Removed
625	Each	Luminaire Support Foundation Removed
625	Each	Pull Box Removed
625	Each	Disconnect Circuit
625	Each	Power Service Removed
625	Foot	Plastic Caution Tape

ITEM 626 BARRIER REFLECTORS

626.01 Description
626.02 Materials
626.03 Layout
626.04 Installation
626.05 Method of Measurement
626.06 Basis of Payment

626.01 Description. This work consists of furnishing and installing barrier reflectors on guardrail blockouts, concrete barrier, retaining wall, and bridge parapets.

626.02 Materials. Furnish materials conforming to:

Barrier Reflectors 719.04

Conform to the manufacturer's recommendations for corrosion resistant fasteners, brackets, or adhesives.

Use barrier reflectors that are mountable on guardrail blockouts, concrete barriers, retaining walls, and bridge parapets. For wall or parapet mount, the barrier reflector may not extend further than 5 inches in a horizontal direction towards the traffic lanes.

626.03 Layout. Lay out all locations to ensure proper placement. The Engineer will approve the layout before installation of the reflectors.

Furnish reflectors at the beginning and the end of all barrier runs and at least one additional point evenly spaced between the termini. Space the reflectors at 100 feet on tangents and on curves of less than 5 degrees. Space the reflectors at 50 feet for curves of greater than 5 degrees.

The Contractor may vary the spacing on tangents and curves of less than 5 degrees from 65 feet to 125 feet in the final 250 feet to achieve even spacing of the reflectors.

If using a buffer end section or similar device on the end of the guardrail, place the first reflector so that it is visible to approaching traffic.

If tying guardrails, barriers, retaining walls, or bridge parapets together in a continuous run, use the total length of the run for determining the number and location of reflectors.

If installing a run of rail or barrier that is at varying distances from the edge of pavement, place a reflector where the run first approaches closest to the pavement. If this results in spacing greater than 125 feet, or 65 feet in cases where 50-foot standard spacing is required, install an additional reflector. If a non-reflectorized impact attenuator is in place, place an additional reflector on the face of the attenuator nearest to, and directed toward, approaching traffic.

626.04 Installation. Attach the reflector with a suitable corrosion resistant fastener or adhesive conforming to the manufacturer's recommendations.

On concrete barriers, retaining walls, and bridge parapets, place the top of the reflector so its height is 26 inches above the near edge of pavement, except that the top of the reflector is at least 3 inches below the top of the concrete barrier.

Install guardrail blockout reflectors on top of the blockout or on the side of the blockout away from traffic. Install guardrail blockout reflectors on the top or side of the blockout nearest the edge of pavement. Install the guardrail blockout reflector so that the reflective surface is above the guardrail.

For guardrail blockout reflectors that are installed on top of the blockout, angle the reflective face approximately 5 degrees towards the nearest travel lane.

Remove loose concrete, rust, dirt, and other loose material from the surface of the concrete barrier using a wire brush. Remove dust created by wire brushing before applying adhesive. Apply adhesive to clean and moisture-free surfaces according to the manufacturer's recommendations.

Ensure that the reflector face is clean and free of dust, dirt, adhesive, or any foreign material after installation.

Except if mounted on a guardrail blockout, rotate the reflective face of one-way reflectors upward from the vertical (or plumb) position 2 to 3 degrees to facilitate "rain washing" of the reflector face.

If specified, use bi-directional reflectors (white/white) on the outside of curves on two-lane highways.

Use one-way and bi-directional barrier reflectors in accordance with the following guidelines:

BARRIER REFLECTORS COLOR & DIRECTION	**One-Way Reflector**		**Bi-Directional Reflector**	
	Left Edge	**Right Edge**	**Left Edge**	**Right Edge**
Two-Lane, Two Way			N/A	White/White
Interchange Ramp			Yellow/Red**	White/Red
Multilane Undivided			N/A	White/White
Multilane Divided				
Multilane Divided with median barrier*		White	Yellow/Yellow	
Multilane Divided without median barrier	N/A	White		

* concrete wall, guardrail or cable rail
** if median concrete wall is present

Use barrier reflectors that are the same color as the adjacent edge line.

The City will classify the reflectors as follows:

Mounting Location	
Concrete barrier, retaining walls, or bridge parapets	
Type 1	Barrier Reflector
Guardrail	
Type 2	Corrosion Resistant Metal Guardrail Blockout Reflector
Type 3	Acrylic or Polycarbonate Plastic Guardrail Blockout Reflector
Type 4	Spring Loaded Guardrail Blockout Reflector
Type 5	L-Type Guardrail Blockout Reflector

626.05 Method of Measurement. The City will measure Barrier Reflector by the number of each in place, completed and accepted.

If a bi-directional reflector consists of two one-way reflectors mounted back-to-back, the City will measure it as one bi-directional reflector.

626.06 Basis of Payment. The City will pay for accepted quantities at the contract price as follows:

Item	**Unit**	**Description**
626	Each	Barrier Reflector, Type ____, (One-Way or Bi-Directional)

ITEM 627 REBOUNDABLE TRAFFIC POST

627.01 Description
627.02 Materials
627.03 Design
627.04 Installation
627.05 Color
627.06 Reflective Strips
627.07 Workmanship
627.08 Method of Measurement
627.09 Basis of Payment

627.01 Description. This work consists of furnishing and installing a high performance surface mounted flexible, reboundable plastic channelization and delineation post assembly. This device can be bonded to asphalt or concrete surfaces, or spun into an embedded cup to provide traffic control in areas requiring a high visibility impact resistance device.

627.02 Materials. Furnish posts made of a durable plastic material that is resistant to impact, ultraviolet light, ozone and hydrocarbons, and that is self-erecting after withstanding multiple vehicle impacts at temperatures of -30°F to +130°F without loss of serviceability. The spin-in post shall include a molded stainless steel 24 mm bolt assembly with minimum of 6 complete threads. The aluminum embedded cup shall have a minimum of 6 interior complete threads.

627.03 Design. The flexible post assembly shall incorporate a round vertical post, a post to base attachment assembly, and a low profile base. The post to base attachment assembly shall be designed so as to make assembly and/or post replacement quick and easy. Posts shall have a uniform diameter, top to bottom.

Minimum post diameter shall be 2 1/4 inches and the maximum diameter shall be 3 1/4 inches.

Post height shall be 36 inches, unless otherwise specified.

Aluminum embedded cup shall have an outside diameter of 2 inches.

Aluminum embedded cup height shall be 4 inches.

627.04 Installation. Install posts in the location and of the color specified in the plans.

Bond temporary posts to the pavement surface using a flexible mastic pad, included with each post. Bonded permanent posts shall be bonded to the pavement surface using a heat applied thermoplastic "super bundy" pad or epoxy. Cover the entire surface of the base with the pad or epoxy. Spin-in permanent posts shall be spun into aluminum embedded cup with the top of the cup being flush with the asphalt or concrete.

627.05 Color. The color of the post shall be yellow, white or orange as dictated by the appropriate section of the Ohio Manual of Uniform Traffic Control Devices (OMUTCD) guidelines for particular application.

627.06 Reflective Strips. On each post, provide two 6-inch high Type G reflective strips of the appropriate color to meet the requirements of the OMUTCD. Locate one strip as close to the top of the post as possible. Allow for a 6-inch gap between the first and the second strips.

White posts shall have silver white strips; yellow posts shall have yellow strips; and orange posts will have white or yellow strips as specified in the plans.

627.07 Workmanship. Ensure that posts exhibit good workmanship and are free of burns, discoloration, contamination and other objectionable marks or defects which affect appearance or serviceability.

627.08 Method of Measurement. The City will measure the number of Reboundable Traffic Posts by the actual number installed and accepted in the units designated, including layout, premarking and surface preparation.

627.09 Basis of Payment. The City will pay for accepted quantities complete in place at the contract prices as follows:

Item	Unit	Description
627	Each	Reboundable Traffic Post - (Color) Installed
627	Each	Reboundable Traffic Post - (Color) (Post Only) Installed
627	Each	Reboundable Traffic Post - Removed

ITEM 628 LONGITUDINAL CHANNELIZER

628.01 Description
628.02 Materials
628.03 Installation
628.04 Basis of Payment

628.01 Description. This work consists of furnishing and installing longitudinal channelizer assemblies consisting of vertical marker panels and/or bollards with black securing arcs, raised separator units including reflective arcs, and the associated end units with their component parts.

628.02 Materials. In addition to complying with the guidelines established in the Ohio Manual of Uniform Traffic Control Devices (OMUTCD) and meeting the requirements set forth in the NCHRP Report 350 OR MASH-08, the longitudinal channelizing device shall meet the following specifications.

The longitudinal channelizer assembly shall include two main components; the base component consisting of raised interlocking units (separator), and the vertical component (channelizer).

1. Base Component

   A. A base component may consist of a series of raised separator units which shall have a width that measures between 10 inches and 12 inches, a height that measures between 3 1/2 inches and 4 inches, and a length that measures between 3 feet and 5 feet. The raised separator units shall also include the proper end unit (male, female, or end/tapered) to either continue or to complete the assembly.

   B. A base component may consist of a stand-alone raised separator that includes a single raised separator unit with tapered ends on both sides. The tapered ends shall provide a gradual increase in height from the pavement level to the top of the separator. The raised separator shall have a width that measures between 10 inches and 12 inches, a height that measures between 3 1/2 inches and 4 inches, and a length that measures between 2 1/2 feet and 3 1/2 feet.

   C. A base component may consist of a single base plate. The channelizer base plate shall be square with no dimension exceeding 12 inches. The base plate shall consist of a single color, either white or yellow, and have a receptacle for the installation of a single vertical channelizer.

   D. All separator units and end units shall have reflective arcs installed.

   E. The color of the base component including the attached reflectors, and of the retroreflective sheeting, shall be in conformance with the pavement marking colors established in the OMUTCD.

2. Vertical Component – Channelizer (Elliptical, Round, or Flat)

   A. The vertical component shall be a High Target Value post made of durable plastic material that is resistant to impact, ultraviolet light, ozone and hydrocarbons and that is capable of withstanding multiple vehicle impacts at temperatures of -30°F to 130°F without loss of serviceability. The vertical component shall have a mounting height between 40 inches and 44 inches above the roadway.

   B. Each channelizer (elliptical, round, or flat) shall meet the following requirements for dimensions and High Intensity Flexible Grade Reflective sheeting, if required.

      i. The elliptical channelizer shall have a width that measures between 8 inches and 10 inches and a height that measures between 34 inches and 38 inches. The elliptical channelizer shall accommodate Type IV High Intensity Flexible Grade Reflective sheeting which has a width that measures between 7 3/4 inches and 8 inches, and a height that measures between 29 inches and 30 inches. A minimum reflective area of 230 to 255 square inches is required.

      ii. The round (tubular) channelizer shall have a minimum diameter of 5 1/2 inches and shall accommodate at least two (2) 4 inch bands of Type IV High Intensity Flexible Grade Reflective sheeting visible from any direction. The color of the bands shall be in conformance with the pavement marking colors established in the OMUTCD. A minimum reflective area of 50 to 100 square inches is required.

      iii. The flat channelizer shall have a width that measures between 6 inches and 9 inches and a height that measures between 20 inches and 29 inches. If reflective sheeting is required, the flat channelizer shall accommodate Type IV High Intensity Flexible Grade Reflective sheeting with a minimum reflective area of 120 to 270 square inches.

628.03 Installation. The Contractor shall install the longitudinal channelizing devices as shown on the plans.

Install the devices such that the associated end units with their component parts and each panel with reflective material will adequately channelize the required area of roadway as per the manufactures recommendations.

The components of the channelizer system shall be inspected by the Contractor and Engineer prior to and after installation. All parts damaged during installation, while in storage, during transportation, or rejected by the Engineer shall be replaced at the Contractor's expense.

If during installation it is found that the underlying road base is composed of unstable material, which can cause the anchor bolts to loosen, the anchors shall be replaced with a larger version or the units shall be re-positioned by re-drilling the separator in a different location.

628.04 Basis of Payment. The City will pay for installing, removing, storing, and re-constructing the longitudinal channelizing system separator units and associated parts at the contract price as follows:

Item	Unit	Description
628	Each	Raised Separator Unit (Color)
628	Each	End Unit, Type_____, (Color)
628	Each	Stand-Alone Raised Separator Unit (Color)
628	Each	Base Unit (Color)
628	Each	Elliptical High Target Value Channelizer with Reflective Sheeting (Color)
628	Each	Round High Target Value Channelizer with Reflective Sheeting (Color)
628	Each	Flat High Target Value Channelizer

		with Reflective Sheeting (Color)
628	Each	Flat High Target Value Channelizer without Reflective Sheeting
628	Each	Reflective Arcs

ITEM 630 TRAFFIC SIGNS AND SIGN SUPPORTS

630.01 Description
630.02 Materials
630.03 Shop Drawings
630.04 Sign Fabrication
630.05 Foundations
630.06 Sign Supports
630.07 Sign Erection
630.08 Sign Shipment and Storage
630.09 Specific Service and Tourist-Oriented Directional Signs
630.10 Covering of Signs
630.12 Removal and Delivery, Storage, Reerection, or Disposal of Signs and Supports
630.13 Inspection
630.14 Method of Measurement
630.15 Basis of Payment

630.01 Description. This work consists of furnishing and installing traffic signs, sign supports, and foundations complete and ready for service. This work also includes necessary excavation and backfill, disposal of discarded materials, and restoration of disturbed facilities and surfaces to a condition equal to that existing before this work started.

630.02 Materials. The acceptance of materials and products is based on Certified Test Data, furnished in triplicate, or on test results of samples according to 106.02, as required by the Engineer.

Transfer manufacturers' guarantees or warranties on all traffic sign material to the City or other maintaining agency upon completion and acceptance of the project.

Furnish materials conforming to:

Concrete, Class COC 6 ..... 499, 511
Steel:
- Structural steel 711.01
- Reinforcing steel 509.02
- U-channel posts 730.015
- Square posts 730.016
- Street name sign supports 730.017
- Tube and pipe 730.01
- Anchor bolts and nuts 730.02
- Poles and arms 730.03
- Base and arm plates 730.04
- Handhole covers 730.05
- Pole caps 730.06
- Arm caps 730.07
- Hardware 730.08
- Stainless steel 730.09
- Stainless steel hardware 730.10
- Messenger wire 732.18

Aluminum:
- Sheet and plate 730.11
- Extrusions 730.12
- Tube and pipe 730.13
- Castings 730.14
- Forgings 730.15
- Welding rods 730.16
- Hardware 730.17

Other materials:
- Decals 725.21
- Reflective sheeting, Type F 730.18
- Reflective sheeting, Type G 730.19
- Reflective sheeting, Type H 730.192
- Reflective sheeting, Type J 730.193
- Nonreflective acrylic opaque sheeting 730.20
- Silk screen inks 730.22

Transparent acrylic electronic cuttable films 730.23
Cantilevered offset brackets 730.24

630.03 Shop Drawings. Furnish shop drawings according to 625.06. Submit sign support shop drawings that cover all design types such as ground mounted, rigid overhead, span wire mounted, and overpass structure mounted supports. On the drawings, show overall height, sign clearance above foundation, span length, sign locations, sign overall heights and widths, and glare shield height and location, if applicable.

630.04 Sign Fabrication. Sign types include flat sheet, double faced, extrusheet, and temporary overlay. Flat sheet signs consist of one-piece units made of aluminum. Double faced signs consist of flat sheet aluminum or extruded aluminum blanks with legend on both sides. Extrusheet signs consist of a number of horizontal panels assembled to form a complete sign. Temporary overlay signs consist of an aluminum sheet covering portions or entire surfaces of extrusheet signs.

Prior to reflective sheeting application, clean aluminum sign surfaces either by total immersion in a tank containing an alkaline solution of the manufacturer's specification or by steam cleaning with an alkaline solution of the manufacturer's specification, followed by a thorough rinsing with running water. After cleaning, etch the surface with an acid solution, and dry. Do not allow cleaned and etched surfaces to become contaminated by contact with oil or grease. Drill or punch bolt holes to finish size.

Use sign designs according to the (a) City Sign Design Manual, (b) OMUTCD and (c) the ODOT Sign Designs and Markings Manual. In case of a conflicting specification statement, the specification document hierarchy shall be in the order listed from (a), highest, to (c) lowest. Use the Standard Alphabets for Traffic Control Devices for positive contrast legends on all guide signs. Do not revise overall sign sizes from what is shown in the plans. The edge space between the border and the text may be adjusted from what is normally used to achieve the sign widths shown. For negative contrast legends, use the Standard Alphabets for Traffic Control Devices. Use capital legends and upper/lower case legends in accordance with the ODOT Sign Designs and Markings Manual. When either is permitted in the ODOT Sign Designs and Markings Manual, use upper/lower case legends.

For flat sheet, double faced mile marker, double faced street name and ground mounted extrusheet signs, use Type G, H or J reflective sheeting for background and reflective legends. For overhead extrusheet signs, use Type H reflective sheeting for the background, and use Type H reflective sheeting for reflective legends, shields and symbols (including hazardous material plaque, airport symbol, arrows and borders). Apply reflective sheeting to the surface according to the manufacturer's recommendations, with no blisters, wrinkles, tears, or blemishes. Do not use reboundable or damage control sheeting for permanent signs.

For reflective legends on flat sheet, double faced street name signs and double faced mile marker signs, use reverse silk screen transparent ink or electronic cuttable film. For nonreflective legends, use direct silk screen black ink or direct applied nonreflective acrylic opaque black sheeting copy. For double faced mile marker signs, use flat sheet aluminum and apply reflective sheeting and legend to both sides.

Street Name Sign faces shall be bonded to 0.063 inch thick sign blanks according to the sheeting manufacturers' recommendation. There shall be 2 sign faces on each sign blank, 1 on each side, unless otherwise noted. Street name legends shall be printed in heights of 4" on 9" blade, 6" on 12" blade, and 8" on 18" blades upper and lower case. Standard FHWA Series D 2000 EX lettering shall be used on all signs 9" and 18" blades and FHWA Series C 2000 EX lettering for all 12" sign blades. Prefixes and suffixes shall be printed in heights of 2, 3, and 4 inch upper and lower case. All letters shall be centered on the vertical dimension and the legend will be centered on the various sign blades horizontally. Street name letter heights will be as follows: 4 inch legend with 2 inch prefix and suffix on a 9 inch blade, 6 inch legend and 3 inch prefix and suffix on a 12 inch blade, and an 8 inch legend and 4 inch prefix and suffix on an 18 inch blade. The minimum distance between the edge of the sign and the first or last letter of the street name, prefix, or suffix shall be 4 inch. See City of Columbus Standard Drawing(s) for fabrication of street name signs.

Extrusheet panels consist of flat sheet aluminum reinforced with aluminum extrusions attached by spot welding. The Contractor may use panels extruded in a single operation in lieu of extrusheet panels. Do not use extruded panels and spot welded panels in the same sign. Bolt together the minimum number of full length, sheeted panels to achieve the sign height, using aluminum bolts, washers, lock washers and nuts. For reflective legends, shields and symbols (including hazardous material plaque, airport symbol, arrows and borders) use direct applied reflective sheeting. Apply all reflective legend on a sign with the same rotation angle orientation. For nonreflective legends, use direct applied nonreflective acrylic opaque black sheeting copy.

For temporary overlay signs, use 0.063 inch thick flat sheet aluminum, with a maximum panel size of 8 × 4 feet. Apply sheeting and legend as described above for extrusheet signs. Attach temporary overlays to extrusheet signs in the shop or field using aluminum blind rivets at a maximum spacing of 18 inches on the peripheries of the temporary overlays and 24 inches within the interior. Position rivots so as not to disturb the legend on the underlying sign.

Use fluorescent yellow-green reflective sheeting for the following signs and plaques: School (S1-1), School Bus Stop Ahead (S3-1), SCHOOL BUS TURN AHEAD (S3-2), SCHOOL ENTRANCE (S3-H3), SCHOOL (S4-3P), School Speed Limit Ahead (S4-5, S4-5a), yellow portions of School Speed Limit (S5-H1), Pedestrian Crossing (R1-6, R1-6b, R1-9), Bicycle (W11-1), Pedestrian (W11-2), Handicapped (W11-9), Bicycle/Pedestrian (W11-15), Trail Crossing (W11-15a), Playground (W15-1), and SAFETY ZONE (W15-H2). Fabricate supplemental warning plaques [such as Advisory Speed (W13-1P), SHARE THE ROAD (W16-1P), Distance (W16-2P, W16-2aP, W16-3P, W16-3aP), Supplemental Arrow (W16-5P, W16-6P, W16-7P) and AHEAD (W16-9P)] from fluorescent yellow-green reflective sheeting when used with a sign above.

Use fluorescent yellow reflective sheeting for all yellow signs, yellow portions of multi-colored signs, and yellow sign post reflectors, except for signs and portions of signs required to be fabricated with fluorescent yellow-green reflective sheeting.

For lighted signs, cover glare shield and rectangular luminaire support tube with nonreflective acrylic sheeting matching the predominant sign color.

Place identification decals of Type G silver white reflective sheeting with silk screened black numerals on signs in accordance with Figure 1. These sign identification decals shall be 6 inches by 3 inches in size and positioned so they can be read horizontally and are clearly visible, not near bolt holes or rivets. Place the decals on the back side of the sign in the lower right-hand corner of rectangular signs, or in an equivalent location of other sign shapes, approximately 3 inches from side and bottom sign edges (for smaller signs, these dimensions may be less).

The Engineer will reject signs delivered at the site without a properly applied decal. At the time of sign installation, indicate the installation data by scratching out the appropriate month and year. Do not allow the sign installation contractor to erect any such signs, or overlays, that do not have a properly completed and affixed sign decal.

FIGURE 1 - STICKER DESIGN

CITY OF COLUMBUS-TRANSPORTATION DIVISION

WARNING!

VANDALS WILL BE PROSECUTED.

TO REPORT DAMAGE CALL 614-645-7393

630.05 Foundations. Locate sign support foundations so the plane of the sign surface is at a right angle to the roadway lanes served (except for signs not intended for this orientation). Install foundations according to 632.14. Furnish and install a ground rod at each rigid overhead and span wire sign support foundation according to 625.16.

Before placing foundation concrete for embedded supports, brace the supports in a vertical position. Seven days after concrete placement, remove bracing for embedded supports and erect signs.

630.06 Sign Supports. Sign supports consist of ground mounted, rigid overhead, span wire, and overpass structure mounted types. Fabricate sign supports according to the applicable requirements of AWS D1.1 Structural Welding Code-Steel. The approval of fabricators according to 501.03 will not apply. Hot-dip galvanize steel structural members according to 711.02. Galvanize steel hardware according to 730.08.

Tighten threaded fasteners, except anchor bolt nuts, by the "turn of the nut" method according to 513.20.

Furnish anchor bolts with a leveling nut, plain washers, lock washer, and anchor nut conforming to 730.02. Use anchor nuts with a plain washer against the base plate upper surface and a lock washer between the plain washer and anchor nut.

Tighten anchor bolt nuts according to 513.20, except that under Table 513.20-3, use the "nut rotation from snug tight condition" from 1/12 to 1/6 turn instead of 1/3 turn.

Apply anaerobic adhesive complying with Federal Standard MIL S 46163, Type II, Grade N to anchor bolts and other threaded connections 1/2-inch diameter or larger, according to the manufacturer's recommendations.

A. Ground Mounted Supports. Ground mounted supports consist of structural sections of the material and weights required. Drive the ground mounted supports into the earth or embed them in concrete, as specified. Install supports in exposed locations in accordance with the performance requirements of NCHRP 350 or MASH. The support lengths shown on the plans are approximate. Determine the exact length of supports before fabrication.

1. Post Supports. Mark each driven post with a line of paint 6 inches above the specified driving depth. Drive posts to the specified depth without bending, distortion, or end mutilation. Do not splice posts.

Do not place posts in drainage ditches. If unable to install the post at the specified location, relocate the post with the Engineer's approval at no cost to the City.

Install posts located in paved areas through a hole provided by sleeving or core drilling. After the post is in position, patch the hole with a non-shrink grout; except when the hole is in asphalt, patch with bituminous material.

For groupings of flat sheet signs in multiple arrangements mounted on posts, provide sign backing assemblies.

For temporary sign supports and their placement, conform to the OMUTCD.

2. Structural Beam Supports. Furnish ground mounted structural beam supports from rolled steel sections. The alternate design shown on ODOT's Standard Drawing TC-41.10 is not acceptable in the City of Columbus. Furnish slip base connections when specified. Bolt the pieces of each beam together, and preload the assembly bolts before delivery to the project. Carefully handle assembled breakaway beams during transportation and erection. Upon erection, perform the final specified torquing on all threaded fasteners.

At least 4 weeks after erecting signs on breakaway beams, inspect the breakaway feature for evidence of shifting or loose fasteners. Re-torque all loose fasteners to specified values. Loosen and re-torque slip base plate fasteners even if no shifting or looseness is detected. Apply anaerobic adhesive to the re-torqued nuts.

3. Pipe Supports. Furnish ground mounted pipe supports from structural steel pipe and tubing. Furnish bolt down anchor installations in existing concrete. Furnish triangular slip base connection when specified.

4. Street Name Sign Supports. Supports for double-faced street name signs shall be either 2.5 inch nominal post size (NPS) (2.875 O.D. x 0.203 inch wall)x 14 foot long post, or 4 inch NPS (4.0 O.D. x 0.226 inch wall) x 21 foot long post fabricated from new, hot dipped galvanized steel pipe in accordance with Section 711.02. All supports shall be embedded in concrete in accordance with Item 499 Class COC 6, 42 according to Item 511. The 2.5 inchNPS supports shall be concreted in a hole with a minimum depth of 3 feet, and a diameter of 10 inches. The post shall have a minimum of 11 feet above ground level. 4.0 inches NPS supports shall be concreted in a hole with a minimum depth of 4 feet, and a diameter of 10 inches. The post shall have a minimum of 14 feet above ground level. All spoils from installation shall be removed from the worksite. The maximum allowable sign area for a 2 sign installation is 10 square feet. If the total street name sign area is greater than 10 square feet, 1 sign support per sign shall be used. For street name sign support installation and locations see City of Columbus Standard Drawing(s).

B. Rigid Overhead Supports. Rigid overhead supports consist of single poles with cantilevered arms, or span types supported between end frames. Furnish anchor bolts and conduit ells (at least two 2-inch minimum diameter) for installation in the foundation. Upon erection, set support poles and end frames on their foundations, and plumb using the leveling nuts followed by secure tightening of all leveling and anchor nuts on the anchor bolts. Plumb poles supporting cantilevered signs following erection of signs as required. Ensure that a minimum of one full thread remains on each anchor bolt above the top of the anchor nut after final tightening. Do not use concrete grouting in the space between the foundation surface and support base.

Provide cover bases or individual anchor bolt covers on support anchor bases regardless of support location.

Furnish overhead sign supports with sign attachment assemblies for attaching extrusheet signs and/or sign hanger assemblies for mounting flat sheet signs to the support chords.

When specified, furnish sign support identification stickers of Type F reflective sheeting listing the support type, design number, span/arm length, county, route, and section number (example: TC-7.65, design 6, 80 ft span, CUY-90-17.58). Apply stickers only when the ambient temperature is above 40 °F. Locate the sticker approximately 8 feet above groundline on the quadrant of the sign support facing approaching traffic. Identify sign supports spanning opposing directions of traffic with two stickers, each on a support member facing traffic.

Rigid span supports consist of a box truss supported by single plane truss end frames. Fabricate box trusses from aluminum or steel tubular members with built-in camber, and mark each section “TOP”. Do not erect box trusses unless at least one sign or damping device approved by the Engineer is installed within 8 hours. Provide for the attachment of a luminaire bracket arm on combination overhead sign supports.

C. Span Wire Supports. Furnish span wire sign supports with sign hanger and messenger wire assemblies. Furnish anchor bolts and conduit ells [at least two 2-inch minimum diameter] for installation in the foundation.

Achieve a span wire sag under load of 4 to 5 percent of the span. Adjust poles to be essentially vertical after span wire tensioning. Securely tighten all leveling and anchor nuts on the anchor bolts. Ensure that a minimum of one full thread remains on each anchor bolt above the top of the anchor nut after final tightening.

Provide cover bases or individual anchor base covers on support anchor bases regardless of support location.

When specified, furnish sign support identification stickers as described in 630.06.B.

D. Overpass Structure Mounted Supports. Mount the supports on the overpass structure so the bottom of the signs are in a level position, regardless of bridge slope.

E. Sign Attachments. Use sign attachment assemblies to attach extrusheet signs to rigid overhead supports. Use sign hanger assemblies to attach flat sheet signs to span wire or rigid overhead supports. Use sign support assemblies to attach flat sheet or extrusheet signs to poles or bridge parapets. Use sign backing assemblies for groups of signs attached to a sign post, and to attach exit number or supplemental panels to an extrusheet sign.

630.07 Sign Erection. Erect signs on ground mounted or overhead supports according to the schematic signing layout. Mount overhead signs so that the bottom of the signs are in a level position regardless of the sag of supporting messenger wire, mast arm rise, chord member or overpass slope. Do not remove an existing sign until the replacement sign is either erected or available for immediate erection. Do not erect a replacement sign on a new support more than 24 hours before the removal of the existing sign.

Install all regulatory, warning, and guide signs prior to opening a new or reconfigured roadway, detour, or temporary route to public travel.

A. Flat Sheet Sign Erection.

Use steel bolts, wide washers, plastic washers, lock washers and nuts. Use bearing plates between the sign and U-channel post at each bolt. Field drill signs mounted on messenger wire or mast arms to match holes in brackets.

B. Extrusheet Sign Erection.

Use self-aligning aluminum mounting clips, stainless steel T-bolts, stainless steel washers, and stainless steel nylon insert lock nuts, to attach extrusheet signs to sign attachment assemblies, beam or U-channel post supports, and for U-channel post sections used to attach exit number and supplemental panels to extrusheet signs. Use aluminum bolts, washers, lock washers, and nuts to assemble extrusheet signs shipped in two pieces. Tighten nuts and lock nuts using hand tools only. Do not use pneumatic, hydraulic, battery, electric or other power-assisted tools.

630.08 Sign Shipment and Storage. Package and ship finished flat sheet signs to assure adequate protection of the sign face, using methods and materials as recommended by the reflective sheeting manufacturer.

Ship extrusheet signs up to 8 feet high completely assembled. Extrusheet signs over 8 feet high may be shipped in two pieces for field assembly. Keep extrusheet signs rigid by back bracing or crating.

Store signs, whether provided by the Contractor or furnished by the City, off the ground in a vertical position with adequate covering or shelter to prevent packing material from getting wet. Immediately remove packing material that does become wet from contact with sign faces to prevent damage to the reflective sheeting.

Identify extrusheet signs on a detachable form on the sign back giving the project number and year, sign reference number, sign legend sketch, and station location. Identify the underlying sign for signs shipped with an attached temporary overlay sign.

630.09 Specific Service and Tourist-Oriented Directional Signs. Maintain existing Specific Service (logo) signs and Tourist-Oriented Directional Signs (TODS) in accordance with 614.07 unless indicated in the plans.

630.10 Covering of Signs. Install temporary covers, and subsequently remove and dispose of them as shown on the plans or as directed by the Engineer. For the covering material, use a sturdy opaque material and obtain the Engineer's approval of the proposed method of covering and attachment. No tape or adhesive shall be used on the face of any sign.

630.12 Removal and Delivery, Storage, Reerection, or Disposal of Signs and Supports. Carefully dismantle signs and sign supports indicated for removal. Either deliver to the City facility as designated by the plan, store on the project, re-erect, or dispose of removed signs and sign supports. To ensure maintenance of adequate traffic control at all times, remove signs only with the Engineer's approval.

Remove sign supports in a manner to avoid damage. Remove sign service to the support by disconnecting and removing cables at the service pull-box. Ensure that connection of remaining cables conforms to 625.18. Remove support foundations to at least 1 foot below subgrade or finished groundline. Backfill and restore surfaces to a condition equal to that existing before the work started and dispose of surplus material according to 603.12 at no cost to the City.

Furnish mounting hardware for signs to be re-erected. Field drill as necessary. Furnish anchor bolts and conduit ells for installation in the foundation for overhead sign supports to be re-erected.

Remove temporary overlay signs so as not to damage the underlying sign.

630.13 Inspection. After erection, the Engineer will inspect signs under both day and night conditions. Correct deficiencies in lateral position or visibility to the Engineer's satisfaction.

630.14 Method of Measurement. The City will measure Ground Mounted Post Support by the number of feet measured from the bottom of the support to the top of the support, and will include driving, hardware for anchor base installation, and furnishing and placing of patching materials for excavations in paved areas. The City will not measure the overlap length of post for the anchor base installation.

The City will measure Foundations for ground mounted pipe supports, ground mounted structural beam supports, rigid overhead sign supports and span wire sign supports by the number of each for one pipe, structural beam, pole, end frame or strain pole, and will include excavation, dewatering, sleeving, casing, reinforcing steel, concrete, backfilling raceways, and when required the 10 foot foundation section of concrete barrier, and the disposal of surplus excavation. Sealing of the 10 foot foundation section of concrete barrier shall be paid for under Item 512 when specified in the plans.

The City will measure Ground Mounted Structural Beam Support by the number of feet measured from the bottom of the foundation to the top of the sign, and will include furnishing and placing of patching materials for excavations in paved areas.

The City will measure Ground Mounted Pipe Support by the number of feet measured from the bottom of the foundation to the top of the sign and will include u-bracket, tubing, posts and hardware for sign attachment, bolt-down anchor and furnishing and placing of patching materials for excavations in paved areas.

The City will measure Street Name Sign Support as the size and number of pipe supports, including excavation and concrete embedment.

The City will measure Street Name Sign as square footage of sign blank, including bracket assemblies, mounting fittings and hardware.

The City will measure One Way Support by the number of feet measured from the bottom of the support to the top of the support, and will include driving, hardware for anchor base installation, and furnishing and placing of patching materials for excavations in paved areas. The City will not measure the overlap length of post for the anchor base installation.

The City will measure Temporary Sign Support by the number of feet or the number of each furnished, erected, maintained, and removed.

The City will measure Breakaway Structural Beam Connection by the number of each set of connection parts with necessary welding and drilling of holes as required for the breakaway function in one beam, and will include base plates, fuse plate, hinge plate, bolt retainer plate, and bolts assembled to specified torques.

The City will measure Triangular Slip Base Connection by the number of each set of connection parts with the necessary welding and drilling of holes as required for the breakaway function in one pipe and will include slip plate, slip base casting, locking collar, bolt retainer plate, coiled pin and bolts assembled to specified torques.

The City will measure Overhead Sign Support by the number of each, and will include anchor bolts and conduit ells furnished for the foundation, sign attachment assemblies, sign hanger assemblies and identification stickers when specified.

The City will measure Combination Overhead Sign Support with light pole extension by the number of each, and will include anchor bolts and conduit ells furnished for the foundation, sign attachment assemblies, sign hanger assemblies and identification stickers when specified. Bracket arms and roadway lighting luminaires are not included.

The City will measure Sign Attachment Assembly by the number of separately itemized assemblies, and will include one overhead sign bracket, U-bolts, clamps, and miscellaneous hardware.

The City will measure Luminaire Support Assembly by the number of separately itemized assemblies, and will include one support arm, other necessary structural members, and miscellaneous hardware.

The City will measure Span Wire Sign Support by the number of each support, and will include two strain poles with span wire clamps and anchor shackles, anchor bolts and conduit ells furnished for foundations, messenger wire, clamps, thimbles, and sign hanger assemblies with hangers, braces, lengths of post, and miscellaneous hardware.

The City will measure Overpass Structure Mounted Sign Support by the number of each support, and will include attachment work and hardware, to attach one individual sign.

The City will measure Sign Hanger Assembly by the number of each, and will include all parts necessary to attach one individual sign.

For pole mounted sign supports, the City will measure Sign Support Assembly by the number of each, and will include brackets, hardware, and posts sufficient to attach each sign or set of signs to an individual pole.

For bridge mounted sign supports, the City will measure Sign Support Assembly by the number of each, and will include post, hardware, and attachment work.

The City will measure Sign by the number of square feet of signs, and will include the furnishing of identification stickers, sign backing assemblies, mounting bolts, washers, nuts, bearing plates, clips, and rivets. For square, rectangular, circular, or irregular shaped signs, the City will determine measurement by multiplying the largest dimensions of width and height. For triangular shaped signs, the City will determine measurement by multiplying the largest dimension of width and one-half the largest dimension of height. The City will include the area of the glare shields for lighted signs as an integral part of the sign.

The City will measure Sign Post Reflector by the number of each, and will include the furnishing of mounting bolts, washers and nuts.

The City will measure Sign, Double-Faced by the number of each, and will include mounting fittings and hardware.

The City will measure Sign Erected by the number of square feet of signs erected, and will include mounting hardware, the assembly of signs that are in more than one piece and the installation of required sign backing assemblies. The City will exclude the furnishing of signs. For square, rectangular, circular, or irregular shaped signs, the City will determine measurement by multiplying the largest dimensions of width and height. For triangular shaped signs, the City will determine measurement by multiplying the largest dimension of width and one-half the largest dimension of height. The City will include the area of the glare shields for lighted signs as an integral part of the sign.

The City will measure Sign Backing Assembly by the number of separately itemized assemblies, and will include back bracing for each group of flat sheet signs attached to a post or posts, or a single assembly for backing posts used to attach an exit or supplemental panel to a guide sign.

The City will measure Covering of Sign by the number of square feet of sign face covered, and will include the subsequent removal and disposal of the covering.

The City will measure Removal and Delivery, Storage, Reerection, or Disposal of Sign by the number of each sign removed and delivered, stored, re-erected or disposed of. Major signs are defined for measurement as being 40 square feet or larger.

The City will measure Removal and Delivery, Storage, Reerection, or Disposal of Support by the number of each support removed and delivered, stored, re-erected or disposed of, and will include removal of foundations and restoration of surfaces. With reerection, the City will include furnishing of anchor bolts, conduit ells, necessary field drilling, and hardware.

630.15 Basis of Payment. The City will not pay for relocating posts from their planned location without prior approval by the Engineer.

The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
630	Each	Ground Mounted Structural Beam Support Foundation
630	Each	Ground Mounted Pipe Support Foundation
630	Each	Rigid Overhead Sign Support Foundation
630	Each	Span Wire Sign Support Foundation
630	Foot	Ground Mounted Support, ___ Post
630	Foot	Ground Mounted Structural Beam Support, ___ Beam
630	Foot	Ground Mounted Support, Pipe
630	Foot	One-Way Support, ___ Post
630	Each	2.5 inch Street Name Sign Support
630	Each	4.0 inch Street Name Sign Support
630	Square Foot	Street Name Sign
630	Foot, or Each	Temporary Sign Support, ___ Post
630	Each	Breakaway Structural Beam Connection
630	Each	Triangular Slip Base Connection
630	Each	Overhead Sign Support, Type TC-___, Design___

630	Each	Combination Overhead Sign Support, Type TC-___, Design___
630	Each	Sign Attachment Assembly
630	Each	Luminaire Support Assembly
630	Each	Span Wire Sign Support, Type TC-17.10, Design ___
630	Each	Overpass Structure Mounted Sign Support, Type TC-___, Design___
630	Each	Sign Hanger Assembly, (Span Wire, Mast Arm)
630	Each	Sign Support Assembly, (Pole or Bridge Mounted)
630	Square Foot	Sign, (Flat Sheet, Ground Mounted Extrusheet, Overhead Extrusheet, Temporary Overlay)
630	Each	Sign, Double-Faced, (Mile Marker)
630	Square Foot	Sign Erected, (Flat Sheet, Extrusheet, Temporary Overlay)
630	Each	Sign Backing Assembly
630	Each	Sign Post Reflector
630	Square Foot	Covering of Sign
630	Each	Removal of Ground Mounted (Major) Sign and (Delivery, Storage, Reerection, or Disposal)
630	Each	Removal of Ground Mounted (Structural Beam, Post, Pipe, Wooden Box Beam) Support and (Delivery, Storage or Disposal)
630	Each	Removal of Overhead Mounted Sign and (Delivery, Storage, Reerection, or Disposal)
630	Each	Removal of Overhead Sign Support and (Delivery, Storage, Reerection, or Disposal), Type TC-___
630	Each	Removal of Overlay Sign

ITEM 631 SIGN LIGHTING AND ELECTRICAL SIGNS

631.01 Description
631.02 General
631.03 Materials and Equipment
631.04 Sign Service
631.05 Signs Wired
631.06 Disconnect Switch
631.07 Luminaire
631.08 Controls
631.09 Electrical Signs
631.10 Removal
631.11 Inspection and Testing
631.12 Method of Measurement
631.13 Basis of Payment

631.01 Description. This work consists of furnishing and installing sign lighting or electrical sign equipment, complete, tested, and ready for service.

631.02 General. Perform installations according to the National Electrical Safety Code, the National Electrical Code and local codes for the area of installation. Furnish overhead sign lighting and integrate electric power with roadway lighting circuits.

Furnish shop drawings according to 625.06.

Conform to the requirements of City Supplement 1063 for the installation or testing of electrical items installed under 631.08 and 631.09.

Protect wire and cable by installing entirely within support structure interiors, enclosures, junction boxes, and rigid or flexible conduit. Ensure that the methods, materials, and locations of splicing and the methods of connecting and identifying wire and cable conform to Item 625, Item 725, and the plans. Furnish grounding systems according to 625.16.

Furnish power service under Item 625.

631.03 Materials and Equipment. Furnish materials and equipment that are new, of first quality, of current design, and free from defects.

Use electrical parts, wire, switches, and other elements of the installations that are of ample capacity to carry the required current without excessive heating or drop of potential.

Ensure that each item of equipment bears a nameplate, indelible marking, or brand that identifies the type, model, catalog number, and manufacturer.

Furnish materials conforming to the following:

Ground rod 625.16
Sealing, conduit..... 625.12
Cable and wire, 600-volt 725.02
Conduit, rigid 725.04
Ballast 725.11
Changeable message sign, electric type 731.03
Internally illuminated fixed message sign 731.05
Sign flasher assembly..... 731.06
School speed limit sign assembly..... 731.07
Conduit, flexible..... 731.08
Timer with enclosure..... 731.10

631.04 Sign Service. Sign service consists of all cable and other equipment to provide a complete electrical service from either an underground or overhead source to the disconnect switch.

Route sign service cable from a pull box to the switch enclosure for overhead supported signs by means of underground conduit, foundation conduit ell, and the interior of the structural member supporting the enclosure.

Route sign service for overpass structure mounted signs through underground and structure attached conduit terminating at a switch enclosure. Attach the conduit by 0.02-inch thick by 3/4-inch wide passivated stainless steel straps spaced at intervals of not more than 5 feet.

Route sign service cable from a distribution system direct drop to the switch enclosure by means of a conduit riser with weatherhead. Form a drip loop into the cable. Use either a cast aluminum or galvanized ferrous metal weatherhead of a threaded design. Attach the conduit by straps as described in the previous paragraph.

For sign service, use single conductor stranded copper. When the connection is to highway lighting distribution and circuit cable, use the same cable for sign service. In other applications, use sign service cable rated at 600 volts minimum and not smaller than 4 AWG.

631.05 Signs Wired. Ensure that signs wired complete the electrical system from the disconnect switch to the luminaires.

Furnish continuous wiring from the disconnect switch to a junction box mounted on the sign support or overpass structure. Install the junction box in a manner that allows sign removal as a unit by the disconnection of the wires and the removal of sign attachment hardware. Install a junction box for each sign.

Furnish continuous wiring from the junction box to the first luminaire and between additional luminaires.

Use wire rated at 600 volts, single conductor and not smaller than 10 AWG.

Route wire on overhead sign supports from the disconnect switch enclosure through structural member interiors. Support wire hanging within the interior of steel vertical members by looping over the J-hook provided. After wiring in the disconnect switch enclosure, seal the nipple in the enclosure back with self-fusing high-dielectric insulating compound.

Assemble flexible or rigid conduit on the sign structure or lighting support arms with condulets, and attach them to the structure by clamps located within 6 inches of each conduit end and separated by not more than 24 inches.

631.06 Disconnect Switch. Install lighted signs with a disconnect switch within a lockable, weatherproof enclosure. For the switch, use a two-pole (minimum), single-throw, fused safety disconnect type, rated at 600 volts, 30 amperes with the fuse size as specified. Furnish a solid neutral bar.

For the enclosure, use stainless steel NEMA 250, Type 4. Furnish space for a chase nipple in the enclosure back. Field drill a hole through the enclosure and install the nipple. Ensure that enclosures also have a screened 1/4-inch diameter weep hole located in the bottom surface.

Furnish each enclosure with at least one padlock. Use padlocks with a bronze or brass lock body and a corrosion protected steel shackle. Key all padlocks for a project alike to use a master 2396 key.

When specified, furnish and install bracket assemblies on existing overhead sign supports or on concrete structures. Use bracket assemblies made of steel, galvanized according to 711.02, or aluminum.

631.07 Luminaire. Include a lamp of the wattage specified.

Locate ballasts integral with the luminaire. Furnish weatherproof ballast housings made from corrosion resistant materials.

631.08 Controls. When specified, furnish photoelectric controls when sign lighting is fed by uncontrolled circuits.

When specified, furnish and install the timer with enclosure to provide automatic school speed limit sign operation.

631.09 Electrical Signs. Furnish changeable message signs that conform to the Contract Documents. The pay item will specify if the display capabilities are limited message or unlimited message. The Contractor may use line units of these types as inserts in a panel sign, singly or grouped to provide a multiline sign. Hardware and software shall be complete to operate and maintain the sign.

Furnish internally illuminated signs consisting of the single or double face type. The sign support is furnished under another pay item. Furnish suspended signs that hang plumb, are properly oriented, and locked in place.

Furnish sign flasher assemblies consisting of a pair of flashing beacons. The sign, support, and foundation are furnished under other pay items.

Furnish school speed limit sign assemblies that conform to the Contract Documents. School speed limit sign assemblies consist of a retro-reflective SCHOOL SPEED LIMIT 20 WHEN FLASHING (R–10–S) sign fitted with a pair of flashing beacons arranged above and below the sign, and one flashing beacon on the back of the sign facing the opposing direction. The flashing beacons shall be yellow LED-type.

631.10 Removal. Carefully remove sign lighting equipment (such as luminaires, disconnect switches, or ballasts) and electrical signs. Removed items become the property of the Contractor.

631.11 Inspection and Testing. Ensure that the sign lighting systems and electrical signs meet all requirements of the ground, cable insulation, and performance tests specified in 625.19. Correct lamps, ballasts, and transformers that failed during the performance test by replacing the faulty component; the entire test period will not require restarting.

During the performance test, make final adjustments to sign lateral position and aiming angles of luminaires to eliminate excessive brightness and glare, and to obtain optimum sign face reflected brightness, uniformity of illumination, visibility, and legibility, to the satisfaction of the Engineer.

631.12 Method of Measurement. All of the following methods of measurement include all hardware necessary to securely mount the associated item including angles, plates, tubes and channels.

The City will measure Sign Service by the number of complete units for each support, and will include conduit, conduit riser, weatherhead, fittings, cables, trenching, and backfilling.

The City will measure Sign Wired and Sign Wired, Overpass Structure by the number of complete units of wiring for each individual sign, and will include junction boxes, rigid or flexible conduit, condulets, clamps, wires, and connectors.

The City will measure Disconnect Switch with Enclosure by the number of each, and will include field drilling and padlocks.

The City will measure Switch Enclosure Mounting Bracket Assembly by the number of each, and will include two brackets and field drilling.

The City will measure Ballast and Photoelectric Control by the number of each separate item.

The City will measure Luminaire by the number of each, and will include lamps and luminaire attachment hardware.

The City will measure Changeable Message Sign by the number of each, and will include cabinet, external enclosures, conduit, electrical, electronic and auxiliary components, and remote control units to provide a fully functional unit.

The City will measure Internally Illuminated Fixed Message Sign by the number of each, and will include lamps and ballasts.

The City will measure Sign Flasher Assembly by the number of each, and will include beacons, flasher control unit with enclosure, and lamps.

The City will measure School Speed Limit Sign Assembly by the number of each, and will include sign, beacons, flasher control unit with enclosure, and lamps.

The City will measure Timer with Enclosure by the number of each, and will include field drilling and padlocks.

The City will measure Removal of sign lighting equipment or electrical signs by the number of each like items removed.

631.13 Basis of Payment. The City will pay for grounding systems under Item 625.

The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
631	Each	Sign Service
631	Each	Sign Wired
631	Each	Sign Wired, Overpass Structure
631	Each	Disconnect Switch with Enclosure, Type ___
631	Each	Switch Enclosure Mounting Bracket Assembly
631	Each	Ballast, Type ___
631	Each	Photoelectric Control
631	Each	Luminaire, Type ___, with ___-watt Lamp
631	Each	Changeable Message Sign, (Limited, Unlimited) Message
631	Each	Internally Illuminated Fixed Message Sign, Type ___
631	Each	Sign Flasher Assembly
631	Each	School Speed Limit Sign Assembly, ___ inches × ___ inches
631	Each	Timer with Enclosure
631	Each	Removal of (Luminaire, Disconnect Switch, Ballast, etc.)

ITEM 632 TRAFFIC SIGNAL EQUIPMENT

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632.02 Contractor Personnel Requirements
632.03 Materials and Equipment
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632.225 Tether Wire
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632.24 Power Service
632.25 Covering of Vehicular and Pedestrian Signal Heads
632.26 Removal of Traffic Signal Installation
632.27 Reuse of Traffic Signal Equipment
632.28 Testing
632.29 Method of Measurement
632.30 Basis of Payment

632.01 Description. This work consists of furnishing and installing traffic signal equipment, complete and ready for service. This work also includes necessary excavation and backfill, disposal of discarded materials, restoration of disturbed facilities, and surfaces to a condition equal to that existing before the Work started, and electrical testing as specified.

Pull boxes, conduits, ground rods, and cable splicing kits required for traffic signal equipment installations are specified in Item 625.

632.02 Contractor Personnel Requirements. Conform to the requirements of City Supplement 1063 for the installation or testing of traffic signal equipment.

632.03 Materials and Equipment. Furnish new materials and equipment of first quality, of current design, and free from defects.

Use electrical parts, wire, switches, and other elements of the installations capable of carrying the required current without excessive heating or drop of potential.

Ensure that major items or assemblies of equipment bear a nameplate, indelible marking, or brand that identifies the type, model, catalog number, and manufacturer.

All coated or painted items shall be shipped in a manner to minimize damage in transit. Surfaces should be protected by foam padding, wrapping in cardboard, spiral wrapping with wax paper, crating, a combination of methods, or any other method selected by the manufacturer which will ensure delivery of undamaged materials. Materials damaged in transit shall be repaired or replaced. All costs associated with correcting damaged material shall be borne by the Contractor.

Furnish materials and equipment conforming to:

Concrete, Class COC 6 ..... 499, 511
Steel*:
Poles, supports, arms, appurtenances
and anchor bases.....730.02, 730.03, 730.04,
.....730.05, 730.06, 730.07,
.....732.12, 732.11
Pedestals 732.15
Backplates 732.22

Hardware 730.08
Stainless steel hardware..... 730.10
Other Items:
Conduit, rigid.....725.04, 725.051, 725.052
Ground rod 725.16
Pull boxes 725.06, 725.08, 725.12
Identifying tags or bands 725.02
Signal heads.....732.01, 732.02, 732.05
Lamps 732.04
Pushbuttons 732.06
Detectors..... 732.08
Wood poles..... 732.13
Down guys..... 732.14
Conduit risers 732.16
Cable supports 732.17
Messenger wire..... 732.18
Cable and wire..... 732.19
Backplates 732.22
Tether Wire..... 732.18

* Acceptance of materials and products is based on certified test data, furnished in triplicate, or on test results of samples according 106.04, as required by the Laboratory.

632.04 Shop Drawings. Furnish shop drawings according to 625.06.

632.05 General. Ensure that major items of traffic signal control equipment used in combination are compatible, interchangeable and, whenever feasible, provided by the same manufacturer or supplier. Perform work in compliance with applicable local laws and codes, the National Electrical Code, the National Electrical Safety Code, the Standard for Electrical Safety in the Workplace and OSHA.

Ensure that the traffic control equipment installed in controller cabinets are shop prewired according to a wiring diagram that conforms to plan and specification requirements of the specific project and intersection, and show all wire harness and field connections required, with abbreviations according to Table 632.05-1. Furnish four (4) sets of a neat and legibly drawn wiring diagram, reproduced on durable paper with each controller cabinet. Place one copy in a plastic envelope mounted horizontally and securely fastened to the inside of the main controller cabinet door. Position the envelope so that its opening is to the right or left and so that it does not block any part of the air filter or the air intake vents located in the door.

Provide the wiring diagrams and service and instructional manuals with the controller cabinet. Clearly note any deviations, changes, additions or other modifications on the diagrams and manuals to reflect the exact equipment provided.

Identify cable and wire by tags or bands at pull boxes and controller cabinets, with size, material, and method of marking conforming to 725.02, except ensure that the identification on the tags or bands conforms to the wiring diagram with abbreviations according to Table 632.05-1. The Contractor may identify field wiring using an indelible pen on a plastic tag instead of embossed letters. Tags shall be a minimum of 1-inch diameter if round and 1-inch by ½-inch if rectangular. Letters shall be clearly legible.

Use spade terminals for wiring connected at signal heads and the wiring connected at terminal blocks within controller cabinets. However, for incoming power wiring, use either spade terminals or bared conductor wire connected to terminal points utilizing screw or spring applied clamping surfaces compatible with both cooper and aluminum wire and providing a positive grip. Neatly lash and fasten completed wiring to interiors with clamps and/or ties.

TABLE 632.05-1 TABLE AND WIRE IDENTIFICATION

Cable	Tag
Ground	GND
Power (2 wire)1∅ 120 volt	AC +AC- or ACN
Power (3 wire) 1∅ 120/240 volt Neutral wire	AC + 1, AC + 2 AC- or ACN
Phase A Phase 1 Phase 1 northbound left turn lanes	∅ A ∅ 1 ∅ 1 NBLT
Phase A, pedestrian signal	∅ A PD
Overlap, phase A + C Overlap, phase 1 + 6	∅ A + C ∅ 1 + 6
Detector lead-in, phase A Detector lead-in, phase 1 Detector lead-in, phase 1 northbound left turn lanes	DET A DET 1 DET 1 NBLT
Detector lead-in, phase A (call type) Detector lead-in, phase 1 (call type) northbound thru lanes	DET A CALL DET 1 CALL NB-THRU
Detector harness [1]	DET A
Interconnect	IC
Pre-emption, fire	PE FIRE
Pre-emption, railroad	PE RR
[1] Place the tag next to the MS plug at the detector amplifier.	

When constructing the traffic control system, cooperate with the agency supplying the electric service. Supply 120 volt, single-phase, two-wire (grounded neutral), 30-amp power to the controller cabinet.

After completion of the 10-day performance test in compliance with 632.28 and until acceptance, the Contractor is responsible for the care and maintenance of traffic control equipment installed or reused as part of the Contract.

Upon acceptance of the project, transfer to the City of Columbus all manufacturers' guarantees or warranties covering installed electrical or mechanical equipment. Furnish four (4) sets of cabinet wiring diagrams per controller cabinet and two (2) sets of service manuals and instructional manuals on installation and maintenance for each different type, model, or system of equipment used on the project.

Include in the service and instructional manuals sections covering the general description of equipment, equipment installation procedures, equipment programming procedures, theory of operation with system description, including block diagrams and detailed circuit diagrams, preventive maintenance, field trouble analysis, bench trouble analysis, troubleshooting analysis chart, wave forms, voltage measurements, voltage measurement charts, parts list, electrical interconnection drawings, schematic and logic diagrams, assembly drawings with pictorial diagrams showing physical locations and identification of each component.

632.051 Acceptance of Signal. The Division of Design and Construction will be the sole agency to accept any traffic signal installation on behalf of the City. The Division will not give permission to the Contractor to either place a proposed signal on flash or activate it or accept any signal installation if any electrical clearance regulations or any OSHA electrical safety clearance are in violation. If any proposed aerial cable is attached to any non-Department of Public Service owned pole, then permission to attach must be granted by the pole owner and attachment confirmation received by the Division of Design and Construction before the signal will be accepted. If a recorded easement is required, deliver a copy of the recorded easement to the Division's Project Engineer before the signal installation is accepted.

632.052 Project Signal Inspection, Signal Plan Changes and Notification. In addition to project personnel, the Division of Design and Construction, Construction Section, Traffic Signal Construction Coordinator will be present to inspect the signal installation at all signals within the jurisdiction of the City of Columbus. Obtain approval for all changes to the signal plans from the Division of Design and Construction, Design Section, prior to their implementation. Contact project personnel to arrange a time and date for a traffic signal preconstruction conference. Do not start signal work prior to this meeting.

632.054 Installation Layout. Engage a Professional Surveyor to locate and mark all stationed signal items using the station numbers and offsets provided in the plans. The Surveyor shall also set controls for mastarm structures when present so the mastarm alignment can be set properly. The Surveyor shall set proper pole, pedestal and cabinet foundation elevations and stake all associated radii so foundations can be aligned properly. Obtain approval from the Division of Design and Construction, Construction Section, Traffic Signal Construction Coordinator for all foundation locations and elevations prior to installing them. The Surveyor shall also stake the right-of-way anytime a stationed traffic signal item is within one (1) foot of the right-of-way. When requested by Engineer, the Surveyor shall set and mark a proposed top-of-curb elevation stake at the back-of-curb or if no curb an edge-of-pavement elevation stake at the proposed edge-of-pavement. Radially align this elevation stake with the radius hub and signal/support pole location stake. Costs incurred for this service shall be incidental to the cost of the project or provided under a construction layout stake item.

632.055 Contractor Access to Existing Controller Cabinet. A representative from the Division of Traffic Management, Operations Section, will be present anytime the Contractor requires entry into an existing control cabinet to perform any cabinet field wiring change or field wiring hookup. Contact the Division of Design and Construction, Construction Section, Traffic Signal Construction Coordinator to make arrangements. Provide a three (3) City workday notice. The representative will act in a supervisory and/or informational capacity only unless otherwise stated in the plans. Existing cabinet wiring that was previously disconnected by Division of Traffic Management will be connected by the Division if connection is required for proper operation of the traffic signal. The Division's representative will oversee the Contractor's connection of all Contractor-installed cable. There is no charge for this representative between the hours of 8am and 3pm, Monday through Friday, excluding City holidays. Outside of these hours, the Contractor shall be charged an hourly rate to cover personnel and equipment costs. A four-hour minimum charge shall apply.

632.056 New Signal Flash Operation. Do not place the signal on "flash" prior to the site generating the volumes required to meet signal warrants at this location. Do not place the signal on flash until the Division of Design and Construction has checked the signal installation and has given the Contractor approval to flash the signal. If any OSHA electrical clearances are found to be in violation, correct all violations before placing the signal on flash. Do not place any signal within an active interconnected system on flash until the system has established reliable communication with the controller. Do not place the signal on flash until all ADA ramp/pathways, permanent pavement markings, vehicular detection, pedestrian push buttons, and lane control signs have been properly installed. The Contractor may use temporary pavement markings in lieu of permanent pavement markings if they reflect the permanent pavement marking layout. Have the stop lines in place prior to the signal being placed on regular operation. During the flash period, install the "SIGNAL AHEAD" (W3-3) and "NEW" (W16-15P-24) signs but keep them covered until the signal is placed in stop and go operation. The signal shall flash for seven (7) days prior to being placed on stop and go operation. If the signal flash sequence is different from the "as per plan" flash sequence, make changes as needed to obtain the proper flash sequence for each time period. During the signal flash period, the mainline signals shall flash yellow.

632.06 Vehicular Signal Head, Conventional. Furnish heads in arrangements such that from one to a maximum of five sections assembled with the specified lens size, color, and circular or arrow configuration form a specific signal face. Mount signal faces alone as a one-way head when backplates are used.

Furnish multi-way heads with top and bottom brackets for mounting purposes. Fit faces of lesser height in multi-way heads with pipe spacers. Close openings unused for mounting purposes with weatherproof caps.

Install signals in a plumb condition, using a balance adjuster only if approved by the engineer. Fit heads mounted on mast arms, except those intended to be rigidly mounted, with a universal hanger allowing the head to swing in both longitudinal and transverse directions. Use drop pipes/extenders of suitable length only when necessary to bring the bottom of the signal heads to a proper roadway clearance. Drop pipes/extenders shall be kept as short as necessary on backplated signals. Use of drop pipes/extenders greater than 1.5 feet in length must be approved by the Engineer. Use disconnect hangers for suspended heads only when specified.

Orient each signal face to its traffic approach, and lock faces in place by the serrated or other type device incorporated in signal housing and support hardware. Before closing serrations on polycarbonate heads, apply a bead of Room-Temperature Vulcanizing (RTV) silicone to all serrated surfaces and then tighten. RTV silicone shall be white to facilitate visual inspection. On heads with dual concentric serrated rings, completely fill the space between the rings with RTV silicone.

Install LED lamps in each section.

When specified, furnish backplates.

632.07 Vehicular Signal Head, Optically Programmed. Furnish heads of this type consisting totally of optically programmed sections unless an intermix of optically programmed and conventional sections is specified. Install approved LED light sources or lamps in each optically programmed section.

Program each signal section according to the plan requirements. Upon completion of the project, deliver all programming tools and devices to the City.

When specified, furnish backplates.

632.08 Pedestrian Signal Head. Mount pedestrian signal heads on the side, not on the top, of a pole or pedestal unless specified otherwise in the plans. Mount the pedestrian signal head on a two-hinged type bracket that is bolted or banded (2 bands per bracket) to the pole, except brackets used on mastarm poles shall be bolted only. Field drill and reinforce the pedestrian head using manufacturer-supplied reinforcement so it fits on the hinged bracket. When two pedestrian signal heads are attached to a single pole, mount the bottom of the mainline signal head at 8 foot above foundation level and mount the second (side street) signal head one-half its housing height above the first. Aim the pedestrian unit at the centerline of the crosswalk area that is opposite of the unit. Also give the pedestrian unit a slight downward angle. Close openings unused for mounting purposes with weatherproof caps.

632.09 Pedestrian Pushbutton. Properly orient and install pushbuttons on poles or pedestals. Service pushbuttons mounted on steel poles by wiring inside the poles. Furnish 3/4-inch diameter holes through the back of the housing and the pole wall, install a rubber grommet, and route wiring through until no external wiring is visible. Plug any unused conduit attachment holes. Attach the housing by machine or self-tapping screws in the housing back wall. Service pushbutton mounted on wooden poles through conduit. Mount the center of the pushbutton 42 inches above the pedestrian pathway surface. Apply a bead of clear silicon sealant to the top of the pushbutton housing (1 inch each side of top center) against the pole to prevent water from entering the back of the pushbutton housing. Furnish one aluminum pedestrian pushbutton sign of the legend and size required with each pushbutton. Mount the bottom of the sign just above the top of the pushbutton. Furnish flat sheet pedestrian pushbutton sign in accordance with 630.04.

632.10 Loop Detector Unit. Install and tune detector units to their loops with the sensitivity set for optimum operation and any interference or cross talk eliminated between other detector units in the cabinet. Perform a field check to ensure that no extraneous detections are occurring by observing each detector unit's operation to determine that a signal occurs only when a vehicle enters its associated loop. If actuations are observed when there is no vehicle in the loop, eliminate the extraneous detections.

632.11 Detector Loop. Saw slots in the pavement for installation of vehicle detector loop wire in the configuration, dimensions, and combinations required. Cut an extension from the loop to the pavement edge to allow wire routing to an adjacent pull box.

Furnish slots 1/16 to 1/8-inch wider than the outside diameter of the loop wire or tubing. The loop slot depth shall be 4 inches. If an existing paved shoulder is 4.5 inches thick or more, the Contractor may install the loop wire in a saw slot cut across the shoulder. When paved shoulders are less than 4.5 inches thick, install the loop wire and its conduit raceway as per City of Columbus Standard Drawing 4300. Use a single 3/4-inch or 1-inch steel conduit raceway for each loop. Ensure that the slot depth provides a covering of not less than 3/4-inch above the uppermost detector wire tubing after the loop installation is completed. Before installing loop detector wire, brush and blow all slots clean of loose material and completely dry. Install loop detector wire according to 632.23. Fill the slots completely with a flexible embedding sealant, prequalified according to the City's Qualified Products List (QPL). Do not disturb slots until sealant has cured. Cured sealant shall be level with or higher than the pavement surface. Take care in placing loop sealant to ensure that all sealant is placed in the saw slot.

632.14 Foundations. Locate support foundations, and stake with the proper elevation. If underground or overhead obstacles are encountered during stakeout, or to correct slope and subsurface difficulties, change foundation location and orientation with the approval of the Engineer. Ensure that the approved location provides a safe clearance from overhead power lines for construction operations, in compliance with applicable Codes. The Contractor is responsible for the correct location, elevation, and orientation for all poles and pedestals installed on the foundations.

Orient one side of the anchor base pole foundation cap parallel to the sidewalk, back-of-curb or edge-of-pavement, edge of the curb ramp, as shown on the signal plans. Make the top of the foundation flush with any adjacent sidewalk or concrete area, except where the ground rises steeply behind the sidewalk or concrete area. In this case, match the back side of the foundation to the ground slope and set the street side of the foundation above the sidewalk or concrete area and completely out of the sidewalk or concrete area. Edge the pole foundation top using a 1/2-inch sidewalk edger and do not chamfer.

Install anchor bolts in the angular position shown in the plans. Install a minimum of two 2-inch conduit ells, used or unused, in each pole foundation.

Excavate for foundations using an earth auger to specified dimensions according to 503.04. Exercise caution when excavating in areas of underground installations to avoid their disturbance or damage. When a cave-in occurs or at the direction of the Engineer, excavate using casing, sleeving, or other methods, with the Engineer's approval according to 732.10. If subsurface obstructions are encountered, remove the obstructions, or replace the excavated material and relocate the foundation, with the Engineer's approval. If bedrock is encountered, the Contractor may reduce that portion of the specified foundation depth within the bedrock up to 50 percent. Perform all necessary dewatering of the excavation.

Perform foundation concrete work according to Item 511, except that the loading restrictions in 511.17 are modified by this subsection. Place the concrete against undisturbed soil or compacted embankment. Form the top of the foundations to a nominal depth of 6 inches below the groundline. Place the concrete foundation, including formed top, in one continuous concrete pour.

For foundations for anchor base type supports, provide the required reinforcing rods, and have anchor bolts and conduit ells accurately held by a template.

Remove forms and templates once the concrete has hardened sufficiently so as not to be susceptible to damage. After 14 days, erect and load supports on anchor base foundations. The Contractor may erect and load supports after 7 days if the tests of two split tensile specimens of concrete yield an average of not less than 400 pounds per square inch.

632.15 Signal Support. Furnish supports with mast arms with the required pole and arm length, anchor bolt circle diameter, and anchor bolt size.

Ensure that the combination signal supports with light pole extension provide for the attachment of a luminaire bracket arm. Adjust anchor base type supports with an initial rake so that when loaded the support poles assume an essentially vertical position.

For support designs not specifically shown on the plans, demonstrate, to the Engineer's satisfaction, that supports are structurally equivalent to the specified design.

Do not use concrete grouting in the space between the foundation surface and support base.

Do not erect signal supports unless at least one signal, sign or damping device approved by the Engineer is installed within 24 hours.

632.16 Strain Pole. Furnish strain poles for the attachment of messenger wire with the required pole length. Use anchor base type strain poles. Adjust anchor base type poles with the initial rake so that when loaded the poles assume an essentially vertical position.

Ensure that the combination strain poles with light pole extension provide for the attachment of a luminaire bracket arm.

Conform to the requirements of 630.06 for threaded fasteners, anchor bolts, anchor bolt nuts, and anaerobic adhesive.

632.17 Wood Pole. Set wood poles in holes excavated by an earth auger to a minimum depth of 6 feet. Use an auger with a diameter approximately 4 inches greater than the pole butt. Hold poles with initial rake, up to a maximum of 12 inches, while tamping backfill into place, so that under messenger wire tensioning conforming to 632.22, the poles assume an essentially vertical position. Furnish backfill material no greater than 1 inch in size, and thoroughly tamp material in lifts not exceeding 6 inches, to the satisfaction of the Engineer. If concrete embedment is specified, brace the poles until the concrete has set.

Liberally coat field holes bored for the attachment of messenger or guy wire with approved creosote base paint and fitted with 5/8-inch thimble-eye through-bolts and 3-inch washers. Securely attach and protect ground wire furnished as part of another work item with a wood or plastic molding for a minimum distance of 10 feet above groundline.

632.18 Down Guy Assembly. Install and tension guy assemblies before erecting signals such that they will resist the major portion of the horizontal loading caused by loading of the messenger wire.

632.19 Pedestal. Furnish pedestals for the support of traffic control equipment with a transformer type base, unless a cast or plate steel base is specified.

632.20 Conduit Riser. Attach risers to poles to provide a wiring raceway and include a weatherhead, conduit, necessary fittings, and pole attached clamps. Attach risers to poles by clamps spaced at intervals not exceeding 5 feet. Paint conduit risers mounted on painted poles to match the poles.

632.21 Cable Support Assembly. Use cable support assemblies to eliminate strain on cables, or groups of cables up to a maximum of four, entering the interior of poles through a weatherhead or mast arm. If required, include a length of messenger wire forming a sling with ends formed of lapped wire, thimbles, and clamps as part of the assembly.

632.22 Messenger Wire. Arrange messenger wire with accessories between two or more poles to provide support and attachment for traffic control equipment. Accessories used with messenger wire include bullrings, thimbles, preformed guy grip dead ends, and three bolt clamps. Furnish bullrings at messenger wire network corners. Use thimbles to attach messenger wire to the shackles of strain pole clamps and bullrings.

Adjust the length of the messenger wire under the load of traffic control equipment so the sag at the lowest point is not greater than 5 percent or less than 3 percent of the span. Attach signal cable to messenger wire with lengths of preformed helical lashing rod that are of a proper internal diameter to tightly secure the cable to the messenger wire. Attach interconnect cable with preformed lashing rod or spinning wire.

632.225 Tether Wire. Arrange tether wire with accessories to stabilize signal heads and prevent excessive swinging and twisting. Install shim washers on hanger pin adjacent to wire entry to prevent any twisting of the head on the hanger. Accessories included with tether wire shall be those shown in the appropriate standard drawing and include pole clamps, anchor shackles, S-hooks yielding element, thimbles, turnbuckles, guy grips, wire rope clips, backup ties, lock wire, safety tie wires, and signal head tether anchors and extenders.

Adjust the tether span to be horizontal on simple spans. On all spans, install tether horizontally and tighten with turnbuckles. Use Bull Rings at all internal corners of the tether span. Install safety ties at all yielding (S-hook) locations to prevent the span end from dropping into the roadway if the S-hook opens. Do not attach electrical or communication cables of any kind to the tether wire. Do not suspend from, or attach to, the tether wire any signs or other devices. Turnbuckles shall be tightened by hand to achieve the tether wire tension shown in the appropriate standard drawing. Measure tether tension with Loos & Co., Inc. Model PT-2, or approved equal. Record tension test results and present a written copy to the Engineer.

632.23 Cable and Wire. Fashion cable at traffic signal equipment weatherhead entrance fittings into a drip loop that extends at least 6 inches below the entrance. Do not allow the cable to chafe on the equipment. Support cables installed in strain poles and signal supports with cable support assemblies according to 632.21.

Do not use splices in any cable or wire, except at the following locations:

A. At the junction of detector wire and lead-in cable.

B. At the junction of power cable and the power supply source or service cable.

For splices allowed in aerial installations, accomplish splicing in weather tight splice enclosures. For splices allowed in underground installations, accomplish splicing in pull boxes or poles where the splice is encapsulated with poured waterproof epoxy insulation according to 725.15.

Install signal cable between signal heads and controller cabinets as per Table 632.23-1. Signal cables shall not be stripped beyond a length necessary to attach individual conductors within the signal head. The jacket shall extend into the signal head enclosure. Install interconnect cable between controller cabinets of different intersections, between an interconnect device and a controller cabinet, or between interconnect devices at different locations, depending on the type of interconnect cable and the design shown in the plans. Route signal and interconnect cable by aerial installation supported by messenger wire or within underground conduit. Do not install signal cable and interconnect cable on the same messenger wire. Ground the supporting messenger wire of interconnect cable.

For underground installation, slack or excess cable shall be placed around the inside perimeter of the concrete pull box.

TABLE 632.23-1 FIELD WIRING HOOKUP

Pedestrian Signal Head - Field Wiring Color Codes

Pedestrian Unit Location	Crosswalk Display	Wire Color
South Crosswalk	Walk	Black
	Don't Walk	Orange
West Crosswalk	Walk	Green
	Don't Walk	Red
North Crosswalk	Walk	Blue
	Don't Walk	White w/Black Tracer
East Crosswalk	Walk	Green w/Black Tracer
	Don't Walk	Red w/Black Tracer
Neutral	---	White

Pedestrian Hybrid Beacon - Field Wiring Color Codes

Signal Face	Wire Color Per Approach
Left Red	Black
Right Red	Red
Yellow	Orange
Neutral	White

Vehicular Signal Head - Field Wiring Color Codes

Signal Display	Wire Color Per Approach
Thru R	Red
Thru Y	Orange
Thru G	Green
L/T ◄R	Black
L/T ◄Y	White w/Black Tracer
L/T ◄G	Blue
R/T R►	Orange w/Black Tracer
R/T Y►	Red w/Black Tracer
R/T G►	Green w/Black Tracer
Neutral	White

White shall be used for the common. Splice all wires in the signal head or PED unit. Use A #14 AWG 2 wire spade terminal for every 2 wires per connection and A #14 AWG 1 wire spade terminal for each single wire connection to connect all wires to all field terminals. Use butt splices on all through wires. All unused wires shall be spliced through and shall have a dead-end terminal at the end of the wire.

Provide loop detector wire consisting of detector wire inserted into flexible polyethylene tubing. When specified or as approved by the Engineer, use of factory-manufactured preformed loops is permitted. Ensure that the tubing encases the wire continuously from the splice at the lead-in cable, through the entire loop turns, and back to the splice. Install loop detector wire in sawn roadway slots forming loops according to 632.11. Furnish the required number of turns of wire installed for each loop, and push the wire carefully into the slots with a blunt tool to avoid damaging the tubing. Run the wire continuously around the loop perimeter and through a slot leading to the pavement edge and by underground conduit to a roadside pull box or pole with 5 feet at each end for slack and splice. Uniformly twist wires and tubing installed in the conduit to the splice with lead-in cable at 3 to 5 turns per foot. Splice the loop ends to lead-in cable, which is connected to the controller cabinet. Join the wires by a mutually twisted in-line splice, rosin core soldered, and wrapped in vinyl or equivalent electrical tape, and encapsulate wires with an approved poured waterproof epoxy insulated splice according to 725.15. Extend and seal the tubing ends into the poured epoxy splice. Also, solder crimped terminals to the conductors and the shield for connections inside the cabinet.

Route lead-in cable within underground conduit or by aerial installation supported by messenger wire.

Install power cable from the power supply source to the controller cabinet or from terminus of service cable to controller cabinet when service cable is used. If multi-conductor power cable is specified, the Contractor may substitute multiple single conductors.

Install service cable aerially from a remote power source to the vicinity of the controller cabinet, the support cable shall not function as the electrical neutral. Furnish connections used with aluminum power or service cable of an approved type for aluminum to aluminum or aluminum to copper connections, and insulate connections with an approved vinyl mastic pad.

632.24 Power Service. Furnish and install all equipment necessary to provide complete 120VAC, single-phase electrical power service to each signal installation as shown on the plans. Supply power from the approximate location as shown on the plans. Make all necessary arrangements with the local electrical power company for connections to establish electrical service. Contact the power company a minimum of four (4) work weeks prior to the need for power.

If a transformer has to be installed to supply power to the signal, make arrangements with the power company to have a pad-mounted or pole-mounted transformer installed as indicated in the plans. Contact the power company a minimum of 16 weeks prior to the need for the transformer.

Charges made by the power company for establishing of the account, extension of company facilities, purchase and installation of a transformer, connection of customer equipment to the power company facilities and energy will be borne by the Contractor.

632.25 Covering of Vehicular and Pedestrian Signal Heads. Cover all signal heads and pushbuttons along with their signs that are installed prior to being used to control traffic or pedestrians. Use only canvas fabric to cover signal heads. Securely lash down the covers so the wind does not rip them from the signal head. Keep covered signal heads dark by disconnecting power to the signal indications. No covered head shall block the view of an operating head. Immediately remove or cover existing vehicular or pedestrian heads that are not functional. Maintain covers, and remove them when directed by the Engineer.

Completely cover the entire signal head, including backplates with reflective borders in such a manner that the reflective borders are not visible.

632.26 Removal of Traffic Signal Installation. Remove signal heads, cable, messenger wire, strain poles, cabinet, controller, or other incidental items required by the Engineer. Remove support foundations in their entirety. If nearby obstructions or utilities do not allow this, and the Engineer approves, remove the foundation to at least 1-foot below subgrade or 2 feet below finished groundline, whichever is greater. Backfill, restore surfaces, and dispose of surplus material according to 105.16, 105.17 and 603.12. Store removed items on the project for delivery to the City, or reuse removed items as part of a new installation on the project under another item of work. Dispose of all items not designated for salvage or reuse. As specified in 614.03, do not remove signals until a new signal system or a temporary traffic control method approved by the Engineer is in operation. Suitably protect stored equipment.

The Traffic Operations Manager is an authorized representative of the City of Columbus working under the supervision of the Administrator of the Division of Traffic Management for the purpose of directing and coordinating traffic control device installation, removal, and maintenance for work within the right-of-way.

Contact the Traffic Operations Manager twenty-four (24) hours, not including Saturday, Sunday, or City holidays, in advance to schedule delivery. No item will be accepted without following this procedure. The Traffic Operations Manager will inspect the condition of all salvaged items being presented for delivery. The Traffic Operations Manager will not accept items damaged by the Contractor. Do not consider any item as being delivered until the Traffic Operations Manager issues a receipt to the Contractor acknowledging acceptance of delivery.

632.27 Reuse of Traffic Signal Equipment. Reinstall or re-erect specified traffic equipment, removed from existing signal installations within the project. Clean and restore reused equipment to an operating condition. Furnish all additional hardware and incidentals necessary to allow reuse of the equipment.

632.28 Testing.

A. General. Furnish all personnel and equipment required to successfully perform the following tests, and furnish to the Engineer six certified copies of complete test records, test reporting forms supplied by the Engineer, or alternate certification approved by the Engineer.

B. Ground Test. Measure each ground rod for earth resistance according to 625.16 and 625.19, except that measurements are not necessary immediately after installation.

C. Short-Circuit Test. Before performing any cable insulation tests or performance test, perform a short-circuit test with a volt-ohmmeter or other approved instrument. Conduct short-circuit tests with electrical loads, power sources, equipment grounds, and earth grounds disconnected. Test signal cable routed to signal heads with connections made to lamp sockets without lamps installed. Measure each conductor against every other conductor and ground to ensure that no short-circuits, cross-circuits, or other improper connections exist. Ensure that continuity does not exist between any conductor and another conductor including ground.

D. Circuit Continuity Test. Temporarily jumper each circuit branch at its termination and the temporarily looped circuit measured for continuity to ensure that no open circuits exist, that the circuit branch is according to plan, that no high resistance connections exist, and that each circuit is properly identified. Test the lead-in cable for loop detector wire before and after splicing the cable to the loop wire. As an alternative, perform the circuit continuity testing of signal head cable by applying 120 volts to each outgoing circuit and observing that only the proper lamps are lighted.

E. Cable Insulation Test. Ensure that the insulation resistance measured to ground is not less than 10 megohms for each conductor of cable or wire terminating at the controller cabinet. Perform insulation testing with all conductors disconnected from their points on the terminal blocks. Measure insulation resistance for the wire of roadway loops after the embedding of the wire with sealant in slots. Include a list of the resistance readings for each conductor in the test results. After completing the cable insulation test, connect all cabinet wiring according to the wiring diagram. Demonstrate to the satisfaction of the Engineer that all circuits are continuous and operating correctly with freedom from shorts, crosses, and unintentional grounds.

F. Functional Test (Contractor Testing of Electronic Signal Components before Primary Power Installation). If any testing of the signal installation or any aspect thereof is planned prior to an approved flash or signal turn-on, notify the Division of Design and Construction, Construction Section, Traffic Signal Construction Coordinator twenty-four (24) hours, not including Saturday, Sunday, or City holidays in advance

and have a special duty officer present for the test to control traffic as needed. Have testing and/or troubleshooting performed by an IMSA Level Two certified technician. If portable power is used, properly connect it to a ground rod reading 10 ohms or less and have a proper regulating device to smooth current. Before the 10-day performance test begins, make the following checks and demonstrate to the Engineer that the system is ready for the performance test. Ensure that the incoming AC voltage is a nominal 120 volts. If the supplied voltage under load is less than 100 or more than 130 VAC, contact the power company to arrange correction. Ensure that the cabinet ventilating fan, fan thermostat, and convenience outlet with lamp is operational. Verify correct timing settings on the controller as shown on the plans. Check all cabinet switches including the power on/off switch and flash switch. Check all controller functions to verify correct operation. Check the detector units to determine which pavement loop is associated with which detector unit. Check the visual indication of detector units to determine that each vehicle class (truck, car, motorcycle, and bicycle) entering sensor areas is detected on the associated detector unit and that no extraneous calls occur when the sensor area is vacant. Occasional extraneous calls may be permitted by the Engineer if necessary to assure detection of small vehicle targets (bicycles and motorcycles). Check the flash switch to verify transfer of signal operation to flash and return to stop-and-go. Check the conflict monitor to verify that it is not activated by normal signal operations or by the manipulation of cabinet switches. If the monitor is activated, determine the cause of the problem and make appropriate changes and adjustments before beginning the performance test. Test the conflict monitor by artificially causing a number of different conflicting indications, and verify that at each test the monitor causes the signals to begin flashing and places the controller in a "stop timing" mode. Obtain artificial causation either by touching a jumper wire between two conflicting load switch outputs or by other methods approved by the Engineer. Ensure that the signal flashes when the monitor is disconnected.

G. Performance Test (Ten Day Test). The Division of Design and Construction requires a ten day test to start after the signal installation is 100% complete which includes establishing data communications if present. The Division will not allow partial tests. At least 7 days before the performance test begins, submit a written request to the Engineer at 1800 East 17th Avenue, Columbus, Ohio, 43219 stating that the signal installation is 100% complete and a start date for the ten day test is requested. The Division of Design and Construction, Construction Section, will monitor the test and will be the sole agency to accept the signal installation on behalf of the City. If less than 100% completion is detected upon inspection by this Division or any malfunction is detected, completely restart the ten day test.

Before acceptance, operate the traffic control system continuously for 10 consecutive days without major malfunction or failure. Immediately replace or repair minor failures (such as lamps, a single detector unit, or an individual signal head, etc.) that do not cause restart of the test. Major malfunctions or failures (such as a master or local controller, interconnect equipment, etc.) will cause termination of the test and, after replacement or repair, the beginning of a new 10-day test. Monitor items that have been repaired or that are replacements for a 10-day period to provide assurance of their reliability. Record, for inclusion in the test result, the method and date of correction of each fault, and the beginning and end of the test.

H. Cabinet Assembly Testing. Perform all cabinet assembly and signal testing and installation following the requirements of Supplemental Specification 1611.

632.29 Method of Measurement. The City will measure Vehicular Signal Head and Pedestrian Signal Head by the number of complete units, and will include all support or mounting hardware, disconnect hangers, closure caps, dimmers, and lamps as required. Optically programmed heads shall include programming. For programming purposes, 8-inch programmed heads shall include one extender tool per project.

The City will measure Pedestrian Pushbutton by the number of individual units, and will include pedestrian pushbutton signs.

The City will measure Loop Detector Unit by the number of individual units, adjusted and tuned, and will include a wiring harness.

The City will measure tether wire by the number of feet in place, and will include all necessary accessories such as pole clamps, safety tie clamps, anchor shackles, S-hooks yielding element, thimbles, turnbuckles, guy grips, wire rope clips, lock wire, safety tie wire, lead sheet, and signal head tether anchors and extenders in accordance with the applicable standard drawing. The City will measure from pole center to pole center, or pole center to bullring, or bullring to bullring. The City will not measure any length of tether wire for attachment to poles or bullrings by bending, lapping or wrapping.

For combination strain poles, the luminaire bracket arm will be a separate item. For combination signal supports, the luminaire bracket arm will be a separate item.

The City will measure Detector Loop by the number of complete detector loops installed in the pavement, and will include pavement cutting, loop detector wire with tubing in place, application of sealant, conduit, trenching, backfilling, and surface restoration from the edge of pavement to the pull box.

The City will measure Strain Pole Foundation, Signal Support Foundation, and Pedestal Foundation by the number of complete units, and will include excavation, dewatering, sleeving, casing, reinforcing steel, anchor bolts, conduit ells, concrete, backfilling, and disposal of surplus excavation.

The City will measure Signal Support, Combination Signal Support, Strain Pole, Combination Strain Pole, Wood Pole, and Pedestal by the number of complete units of each, and will include pole arms, weather-heads, and blind half couplings, anchor bolts and conduit ells furnished for foundations.

The City will measure Down Guy by the number of individual units, and will include messenger wire, pole clamp or thru-bolt, washer, clamps, guy grips, insulator, guy guard, and anchor.

The City will measure Conduit Riser by the number of complete units, and will include weatherhead, conduit, fittings, clamps, and hardware.

The City will measure Messenger Wire by the number of feet in place, and will include all necessary accessories such as, grips, thimbles, clamps, bullrings, and lashing rod. The City will measure from pole center to pole center, or pole center to bullring, or bullring to bullring. The City will not measure any length of messenger wire for attachment to poles, or bullrings by bending, lapping, or wrapping.

The City will measure Signal Cable, Phone Interconnect Cable, Loop Detector Lead-In Cable, Power Cable, and Service Cable by the number of feet in place. Cable inside of poles shall include cable support assemblies. Aerial cable shall include pole attachment hardware, splices, splice enclosures, and ground connection. Lead-in cable shall include poured epoxy insulated splices. The City will measure: (1) horizontally from center-to-center of pull boxes, poles, cabinets, power sources, and signal heads with an additional allowance of 5 feet at each pull box and terminating points for slack and connections; and (2) vertically between pole or conduit outlets. If single-conductor power cable is substituted for multi-conductor cable, the City will measure required length of multi-conductor cable.

The City will measure Power Service by the number of complete units, and will include, all necessary hardware, purchase and installation of transformer, installation of transformer pad when required, and ground wire connection.

The City will measure Covering of Vehicular Signal Head and Covering of Pedestrian Signal Head by the number of individual signal heads covered, and will include materials and labor to erect, maintain, and remove the covering.

The City will measure Removal of Traffic Signal Installation by the number of installations removed, and will include storage when required.

The City will measure Removal of (*Item*) and (*Storage or Reerection*) by the number of specific traffic signal installation parts (such as a signal head, controller unit, or pole) removed, and will include storage when required.

The City will measure Reuse of (*Item*) by the number of traffic signal equipment items reused, and will include cleaning, and restoring.

632.30 Basis of Payment. The costs to arrange service by the supply agency are included under Power Cable.

The costs of personnel, materials, equipment, electrical energy, and incidentals required to conduct performance tests are included under the contract unit price for the respective items tested.

The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
632	Each	Vehicular Signal Head, (Aluminum or Polycarbonate), ___ - Section ___ inch Lens (with Backplate)
632	Each	Vehicular Signal Head, Optically Programmed, (Aluminum or Polycarbonate), ___-Section, ___ inch Lens, (with Backplate)
632	Each	Pedestrian Signal Head)
632	Each	Pedestrian Pushbutton
632	Each	Loop Detector Unit
632	Each	Detector Loop
632	Each	Strain Pole Foundation
632	Each	Signal Support Foundation
632	Each	Pedestal Foundation
632	Each	Signal Support, Type ___, Design ___
632	Each	Combination Signal Support, Type ___, Design ___
632	Each	Strain Pole, Type 4170, Design ___
632	Each	Combination Strain Pole, Type 4170, Design ___
632	Each	Wood Pole, Class ___, (*Length*) ___ feet
632	Each	Down Guy
632	Each	Pedestal, (*Length*) ___ feet
632	Each	Pedestal, (*Length*) ___ feet, Transformer Base
632	Each	Conduit Riser, ___ inch Dia.
632	Foot	Messenger Wire, (*No.*) Strand ___ inch Dia., with Accessories
632	Foot	Signal Cable, ___- Conductor, ___ AWG
632	Foot	Interconnect Cable, ___- Conductor, ___ AWG
632	Foot	Loop Detector Lead-In Cable
632	Foot	Power Cable, ___- Conductor, ___ AWG
632	Foot	Service Cable, ___- Conductor, ___ AWG
632	Each	Power Service
632	Each	Covering of Vehicular Signal Head
632	Each	Covering of Pedestrian Signal Head
632	Each	Removal of Traffic Signal Installation
632	Each	Removal of (*Item*) and *(Storage or Reerection*)
632	Each	Reuse of (*Item*)
632	Foot	Tether Wire, with Accessories

ITEM 633 TRAFFIC SIGNAL CONTROLLERS

633.01 Description
633.02 Contractor Personnel Requirements
633.03 Materials and Equipment
633.04 Shop Drawings
633.05 General
633.06 Testing and Prequalification
633.07 Controllers
633.08 Cabinets
633.09 Cabinet Riser
633.10 Foundations
633.11 Controller Work Pad
633.12 Flasher Controller
633.13 Not Used
633.14 Not Used
633.15 Not Used
633.16 Training
633.17 Not Used
633.18 Uninterruptible Power Supply (UPS)
633.19 Method of Measurement
633.20 Basis of Payment

633.01 Description. This work consists of furnishing and installing traffic signal control equipment, including controllers, cabinets, auxiliary equipment, and specified accessories, completely wired, at the locations shown on the plans and ready for service.

633.02 Contractor Personnel Requirements. Conform to the requirements of City Supplement 1063 for the installation or testing of traffic signal equipment.

633.03 Materials and Equipment. Furnish new materials and equipment of first quality, of current design, and free from defects. For warranted items, the warranty shall begin on the date of Final Acceptance of the Project as defined in 109.11.

Use electrical parts, wire, switches, and other elements of the installation capable of carrying the required current without excessive heating or drop of potential.

Ensure that each item of equipment bears a nameplate, indelible marking, or brand that identifies the type, model, catalog number, and manufacturer. Use equipment conforming to the types, models, and systems specified.

Furnish material and equipment conforming to:

Concrete, Class COC 6 (cabinet foundations and work pads) 499, 511
Conduit 725.04, 725.051, 725.052
Controller unit 733.02
Cabinet and auxiliary equipment 733.03
Cabinet riser 733.04
Flasher controller 733.05
Uninterruptible Power Supply 733.09

633.04 Shop Drawings. Furnish shop drawings according to 625.06.

633.05 General. Ensure that major items of traffic signal control equipment used in combination are compatible, interchangeable, and, whenever feasible, provided by the same manufacturer or supplier.

Ensure that controller cabinets are shop prewired according to 632.05.

Provide four (4) hard copies and one (1) electronic copy of the cabinet wiring schematics, one (1) hard copy of the service manual and one (1) hard copy of the instructional manual per cabinet at the time of cabinet delivery. Clearly note all deviations, changes, additions, or other modifications on the diagrams and manuals that are appropriate to reflect the exact equipment to be provided. Store copies of diagrams and manuals in a plastic envelope mounted horizontally and securely fastened to the inside of the main cabinet door. Position the envelope so that its opening is to the right or left and so it does not block any part of the air filter or the air intake located in the door.

Include in the service and instructional manuals sections covering the general description of equipment, equipment installation procedures, equipment programming procedures, theory of operation with system description including block diagrams, and detailed circuit diagrams, preventive maintenance, field trouble analysis, bench trouble analysis, troubleshooting analysis chart, wave forms, voltage measurements, voltage measurement charts, parts list, electrical interconnection drawings, schematic and logic diagrams, assembly drawings with pictorial diagrams showing physical locations and identification of each component.

Before beginning the 10-day performance test, replace or modify these documents as necessary to reflect current conditions. Upon completion of the work and performance test, replace and modify these documents as necessary.

Transfer manufacturers' guarantees and warranties on all installed traffic signal control equipment to the City upon completion and acceptance of the project.

If required by the plans to install equipment furnished by others, store and care for the equipment upon receipt.

633.06 Testing and Prequalification. For all traffic control equipment, perform functional tests and a 10-day performance test according to 632.28. Do not clear conflict monitor logs during the 10-day test. Ensure that logs note power-up to start the test and all events until the test is complete. Restart the test upon correcting a noted event. Notify the Engineer at least 3 days before beginning the 10-day performance test. The Engineer will notify the maintaining agency of the beginning of the test. Ensure that the following testing and prequalification requirements are met:

A. For traffic control equipment required by this specification to meet NEMA Standards Publication TS-1 or TS-2, conform to the following:

1. Furnish a certified test report indicating compliance to all requirements of NEMA Standards Publication TS-1 or TS-2 as applicable.

2. Furnish the name and location of the laboratory testing facility as well as the identification of the principal personnel who conducted the equipment testing and a summary of their qualifications.

3. Ensure that the laboratory provides City representatives access to those parts of the laboratory where the testing was done.

4. Upon request, furnish a copy of the actual test data results for review and analysis.

633.07 Controllers. Install controller units, consisting of the timing unit, software, and signal timing, into the specified type of prewired cabinet.

Program controller units as shown on the plans unless otherwise directed by the Engineer. If the plan timing data or the supplemental timing data supplied by the Engineer does not exactly fulfill the timing requirements of the installed equipment, notify, in writing, the Engineer of the problem and identify the discrepancies. The Engineer will consult with the maintaining agency and notify the Contractor within 2 weeks. After programming, briefly operate controllers, with the signals turned off by means of the signal shutdown switch, to ensure that operation is reasonable and conforms to the plans.

633.08 Cabinets. Mount cabinets by attaching to pedestal or pole or by installing on a concrete foundation. Arrange foundation mounted cabinets so that control equipment, terminal blocks, or shelves are no closer than 6 inches to the top of the foundation. Attach pole or pedestal mounted controller cabinets at a height that allows convenient access to all controller components by service personnel.

Make field connections for the conductors of signal cable, power cable, interconnect cable, and detector lead-in cable. Make the signal cable field connections according to 632.23. Neatly arrange and route all field wiring to the appropriate terminal blocks. Identify field wiring according to 725.02 except mark with either indelible pen or embossed letters.

Except for power wiring, fit field wiring entering the cabinet with spade terminals to ensure a good connection. For incoming power wiring, either use spade terminals or connect the bare conductor wire to terminal points utilizing screw or spring applied clamping surfaces compatible with either copper or aluminum wire and providing a positive grip. After completing field wiring, seal the conduit entering the cabinet in an approved manner with a removable sealing compound (no foam sealants), or a molded plastic or rubber device that is compatible with the cable jacket, the insulation, and the conduit material.

For foundation mounted cabinets, seal the joint between the controller cabinet and the foundation with a quality, clear silicone caulk.

When future phasing configurations are shown on the plans, furnish the cabinet and hardware to accommodate the future operation through only the future addition of load switches and detector units.

633.09 Cabinet Riser. Cabinet risers provide an extension of the cabinet between the ground mounted cabinet and the foundation. Bolt the riser to the foundation, and bolt the cabinet to the riser.

Use a type (size and shape) of cabinet riser compatible with the type of controller cabinets specified for the project.

Seal the joints between the controller cabinet and cabinet riser, and between the cabinet riser and foundation with a quality, clear silicone caulk.

633.10 Foundations. Construct foundations for controller cabinets according to 632.14, except that excavation by earth auger is not required and the foundation may be mass concrete that does not require reinforcing steel. Hold anchor bolts, conduit ells, and similar appurtenances in the proper position until the concrete has set. Pour foundations separately from controller work pad.

633.11 Controller Work Pad. Construct controller work pad according to 608.03, except that transverse joints are not required. The controller work pad shall be constructed per Standard Drawing 4162. Provide the top of the pad nominally 1 inch above ground line. If the controller cabinet has both front and back doors, install a work pad for each door. Pour controller work pad separately from foundations.

633.12 Flasher Controller. Furnish and install a flasher controller with cabinet and mounting hardware when indicated. The flasher controller is for the operation of flashing beacons.

633.13 Not Used.

633.14 Not Used.

633.15 Not Used.

633.16 Training. Furnish training for the traffic signal control equipment installed as part of the Contract. Furnish all handouts, manuals, and product information. For the training, use the same models of equipment furnished for the project. The City shall furnish the facilities in which the

training will take place. Furnish all media and test equipment needed to present the training. Unless otherwise shown on the plans, the minimum training requirements are as follows:

A. Sixteen hours on how to operate the system, analyze system performance, and revise critical operating parameters.

B. Eight hours of field trouble-shooting and maintenance procedures.

C. Eight hours of follow-up training after the City has operated the system for a minimum period of 30 days.

D. Four hours for preemption device training if emergency vehicle preemption is shown on the plans.

633.17 Not Used.

633.18 Uninterruptible Power Supply (UPS). Furnish and install a Battery Backup UPS system to provide uninterruptible, reliable, emergency power to a traffic signal intersection in the event of a power failure or interruption. The transfer from utility power to battery power shall not interfere with the normal operations of the traffic controller, conflict monitor or any other peripheral devices within the traffic control system. The system shall be self-contained including all UPS hardware and the required number of batteries. A ground rod shall be provided for free-standing UPS cabinets.

Seal the joints between the controller cabinet and the UPS cabinet and between the UPS cabinet and foundation with a quality, clear silicone caulk.

633.19 Method of Measurement. The City will measure Controller Unit with Cabinet, *size*, *mounting type* by the number of each complete unit, and will include controller unit with software, all required auxiliary equipment, loop detector units, and a prewired cabinet, with all items completely wired and tested. Ground mounted cabinets will include anchor bolts and conduit ells for installation in the foundation. Pole mounted cabinets will include pole mounting hardware.

The City will measure Controller Unit by the number of each controller timing unit with software, and will include any signal timing programming or installation. The City will measure Controller Unit, Furnish Only by the number of each controller timing unit with software, and will exclude any signal timing programming or installation.

The City will measure Cabinet, *size*, *mounting type* by the number of each complete prewired cabinet installed, and will include all required auxiliary equipment and loop detector units (excluding controller unit), with all items completely wired and tested. Pole mounted cabinets will include pole mounting hardware. The City will measure Cabinet, *size*, *mounting type*, Furnish Only by the number of each complete prewired cabinet, and will include pole mounting hardware and anchor bolts, but will exclude installation, controller unit, and detector units.

The City will measure Cabinet Riser by the number of each unit, and will include materials, mounting hardware, and installation.

The City will measure Cabinet Foundation and Controller Work Pad by the number of each complete unit, in place, complete and accepted, and will include excavation, concrete, backfilling, and disposal of surplus excavation. Cabinet foundation will include anchor bolts and conduit ells for installation in the foundation and preformed joint filler between the foundation and adjacent paved areas.

The City will measure Flasher Controller by the number of each complete flasher assembly with cabinet installed and tested.

The City will measure Training on a lump sum basis, and will include providing the instruction materials, instructor travel expenses, and test or media equipment for presenting the training material.

The City will measure Uninterruptible Power Supply by the number of each and will include all equipment, testing and certifications.

633.20 Basis of Payment.

The City will pay for accepted quantities at the contract unit prices as follows:

Item	Unit	Description
633	Each	Controller Unit with Cabinet, size, mounting type
633	Each	Controller Unit
633	Each	Controller Unit, Furnish Only
633	Each	Cabinet, size, mounting type
633	Each	Cabinet, size, mounting type, Furnish Only
633	Each	Cabinet Riser
633	Each	Cabinet Foundation
633	Each	Controller Work Pad
633	Each	Flasher Controller
633	Lump Sum	Training
633	Each	Uninterruptible Power Supply

640 PAVEMENT MARKING

ITEM 641 PAVEMENT MARKING—GENERAL

641.01 Description
641.02 Materials
641.03 General
641.04 Equipment
641.05 Pavement Preparation
641.06 Layout and Premarking
641.07 Line Placement Tolerance
641.08 Marking Types
641.09 Two-Way Radio Communications
641.10 Removal of Pavement Markings
641.11 Deduction for Deficiency
641.12 Method of Measurement
641.13 Basis of Payment

641.01 Description. This specification gives general requirements for various kinds of retroreflective pavement markings. Deviations from these general requirements are covered in the specific requirements for each marking type.

Place all pavement markings according to the OMUTCD.

641.02 Materials. Use marking materials that are a formulation, identified by a manufacturer's code number, and certified by the ODOT Laboratory and that have the same composition as the prequalified marking material.

.Materials and manufacturers will be listed on the City's Qualified Products List.

Remove materials delivered and applied without ODOT Laboratory approval. Remove ODOT Laboratory tested materials not meeting specifications from the project site.

Furnish a material safety data sheet (SDS) for each material, including resin, catalyst, primer, adhesive, activator, glass beads, and cleaning solvent, to be used on the project to the Engineer before material delivery. Inform workers of the location of all SDS and allow workers an opportunity to review them.

641.03 General. Apply lines as solid, broken, or dotted lines, either singly or in combination, as shown on the plans. Apply broken lines in a 40-foot cycle consisting of a 10-foot dash and a 30-foot gap between broken lines, unless otherwise shown on the plans. Use an accurate striping mechanism that is capable of being easily adjusted to retrace existing broken markings or to apply new materials at the correct spacing. Begin broken lines that are to be applied over plainly visible existing broken lines within 6 inches of the beginning of the existing broken line, unless otherwise directed by the Engineer. Apply dotted lines in an 8-foot cycle consisting of a 2-foot dot and a 6-foot gap between dots for line extensions and in a 12-foot cycle consisting of a 3-foot line segment and a 9-foot gap for lane drop/add markings.

Fill gaps that were not marked as a result of template use for spray-applied auxiliary markings with marking material after the template is removed. If applying extruded thermoplastic, the Contractor may leave small gaps in arrows or letters resulting from template use unfilled.

Ensure that pavement markings are free of uneven edges, overspray, or other readily visible defects that detract from the appearance or function of the pavement markings.

Ensure that lines are sharp, well defined, and uniformly retroreflective. Apply the lines to the width specified ±1/4 inch. Fuzzy lines, excessive overspray, or non-uniform application are unacceptable. The Engineer will inspect lines at night to verify proper retroreflectivity. Correct pavement markings that are improperly applied, located, or reflectorized. Reapply lines applied with insufficient material quantities according to 641.11, 644.04 or 648.05. Remove improperly located lines according to 641.10, and apply new lines in the correct locations.

Reapply any lines applied with non-specification materials.

Obtain the Engineer's approval for methods and equipment used for pavement preparation, marking, and marking removal. Keep glass beads dry during storage and before use.

Furnish to the Engineer at least 3 days in advance of installation current copies of the manufacturer's instructions and recommendations for application of any marking material, including primer, activator, catalyst, and adhesive, shown on the plans. Schedule and perform other construction work, such as shoulder paving, seeding, and mulching in a manner to avoid damage to applied pavement markings.

Do not apply pavement marking materials to the reflector of a plowable raised pavement marker. Interrupt the application of the pavement marking line at each raised pavement marker where marking material would otherwise be applied to the marker's prismatic reflector. Provide a maximum gap in the marked line of 18 inches at each marker. Remove pavement marking material applied to a prismatic reflector surface, or replace the reflector that same workday. If material must be removed from the reflector, restore the reflector's brightness to its prior condition.

641.04 Equipment. Equip long line pavement marking equipment for traffic paint, epoxy, thermoplastic and work zone marking Item 642 with a computerized Data Logging System (DLS), including a cab mounted display which shows the actual material application rate and film thickness. For center line, lane line and edge line markings, when the length of marking exceeds 0.5 miles of continuous line equivalent, document the following with the DLS:

1. Measure and record application vehicle speed to nearest 0.1 MPH,
2. Measure and record weight and/or volume amount of material used by color,
3. Measure and record weight of glass beads,
4. Measure and record pavement surface temperature,
5. Measure and record air temperature,
6. Measure and record dew point,
7. Measure and record humidity,
8. Calculate and record average material application rate and film thickness over the section painted.

Record as a separate DLS report line entry the above information for each route section painted, when the length of center line, lane line and edge line marking exceeds 0.5 miles of continuous line equivalent. A route section is defined as one direction of a contiguous section of highway (without breaks) with the same route number designation. DLS documentation is not required for center line, lane line and edge line markings of 0.5 miles or less, and for channelizing lines of any length.

If the DLS equipment fails, finish that day's work only and resume when the DLS equipment is working.

The City will provide ODOT's DLS short form and long form, which prescribes the correct DLS report format and content prior to beginning of work.

On the first working day following application of markings requiring documentation with the DLS or upon demand, furnish the Engineer a copy of the DLS report in ODOT DLS short report format. The DLS report can be provided in one of the following methods, which should be agreed upon at the preconstruction meeting:

1. hand delivery of paper report
2. fax delivery of paper report
3. e-mail of Excel spreadsheet file
4. disk or flash drive transfer of Excel spreadsheet file

Within two weeks of the date of application of markings requiring documentation with the DLS, furnish the Engineer the Excel spreadsheet file of the DLS report in ODOT DLS long report format by e-mail at the e-mail address provided at the preconstruction meeting.

At the end of the project, furnish the Engineer all Excel spreadsheet files in ODOT DLS long report format.

Ensure that each DLS has an annual calibration of all mechanical and electrical components and its software function and output confirmed by the DLS manufacturer or their designated representative. Provide evidence of the annual calibration by affixing a signed and dated stamp or seal to the inside of the driver's door of each striper.

641.05 Pavement Preparation. Clean all visible loose or foreign material from the surface to be marked. Equip the pavement marking equipment with an air jet to remove all debris from the pavement in advance of the applicator gun. Operate the air jet when marking material is being applied, and synchronize it with marking material application. Power-broom clean all surfaces where gore markings or edge lines are to be applied. If required by the Engineer, also power-broom clean other surfaces. Do not apply marking to portland cement concrete until the concrete in the areas to be marked is clean of membrane curing material and is dry.

641.06 Layout and Premarking. Lay out the locations of all lines, words, and other symbols to ensure their proper placement. Do not start marking operations until the Engineer or the Engineer's representative has approved the layout and premarking lines. If applying longitudinal or transverse lines, use existing lines, construction joints, or premarking to guide this marking equipment.

On projects where resurfacing or other operations will result in obliteration of the existing pavement markings, establish reference points to ensure proper placement of restored markings. If existing markings are to be retraced, verify any adjustment in the location with the Engineer.

Establish "T" marking of no-passing zones according to the plans or a no-passing zone log provided by the Engineer.

Locate premarking from survey data or reference points, and offset it so as to parallel the theoretical edge of the marking lines at a maximum distance of 1 inch. Use templates for the layout of arrows, words, and other symbols. Place premarking for longitudinal lines at 40-foot intervals, and do not exceed 2 inches in width or 12 inches in length. Locate premarking for auxiliary markings from the plans or schematic forms provided by the Engineer.

641.07 Line Placement Tolerance. Ensure that pavement marking lines are straight or smoothly curved, true to the alignment of the pavement, and do not deviate laterally from the proper location at a rate of more than 2 inches in 100 feet. The Engineer will not allow any deviation greater than 3 inches. Remove improperly located lines according to 641.10 and apply new lines in the correct locations.

641.08 Marking Types. Apply marking materials at the rate or thickness specified in 642.04, 644.04, 645.03, 646.05, 647.04, or 648.05 and, except for parking lot stall markings, ensure that they are uniformly retroreflective. Ensure that portions of parking stalls that are adjacent to street traffic are retroreflective. Pavement markings consist of the following types:

A. Edge Lines. Place edge lines as continuous 5-inch wide stripes. Locate the center of the stripe 6 inches from the edge of the pavement or as approved by Engineer.

B. Lane Lines. Place lane lines as 5-inch wide, white stripes between contiguous lanes of pavement carrying traffic in the same direction. Place them as broken lines unless specified solid. Offset lane lines to the left of the longitudinal joint, if present, or the theoretical line lying between contiguous lanes, if a joint is not present. Ensure that the nearer edge of the stripe is 2 inches to the left of the joint or line. Do not place lane lines through intersections.

C. Center Lines. Place center lines as single or double yellow stripes between contiguous lanes of pavement carrying traffic in opposite directions. Center line marking includes two-way left-turn lane striping and the outline of left-turn islands. Make each stripe 5 inches wide, solid or broken as specified.

D. Channelizing Lines. Place channelizing lines as continuous 10-inch wide white stripes.

E. Stop and Crosswalk Lines. Place stop lines as solid 20-inch wide white stripes. -Place latitudinal lines Type II crosswalk lines as solid 24 inch wide white lines within the Type I crosswalk lines. Place Type I crosswalk lines as solid 10 in wide white lines within crosswalk. See Standard Drawing for details.

F. Transverse/Diagonal Lines. Place transverse/diagonal lines as solid 20-inch wide stripes, of the color specified, and at an angle to the direction of travel.

G. Curb and Island Marking. Prepare exposed surfaces and curbs and paved islands according to 641.05. In addition, remove and dispose of all visible loose or foreign material, including vegetation, on and immediately contiguous to surfaces to be marked.

H. Symbol Markings. Place all railroad, school, bicycle and handicap symbol markings using white markings. A railroad marking includes the 16-inch crossbuck, two 72-inch "R"s, two 24-inch transverse lines, and a stop line. A school marking includes the word "SCHOOL" and two 20-inch transverse lines. A shared lane marking includes the bicycle symbol and two sharrows.

I. Parking Lot Stall Marking. Place parking lot stall marking lines as continuous 5-inch wide white stripes.

J. Lane Arrows. Place lane arrows using white markings.

K. Words on Pavement. Place words on pavement using white markings.

L. Dotted Lines. Place dotted lines using the width and color specified.

M. Bike Markings. Place bike lane markings using white markings.

N. Speed Hump Markings. Place speed hump markings using white markings.

O. Yield Lines. Place yield lines as solid white 24-inch isosceles triangles pointing toward approaching traffic.

P. Lane Marking with Contrast 1.5" Black Border. The 1.5" black border shall be used on all arrow symbols and words and on all white longitudinal lines as shown in Table 645.03-1 that are placed on and/or grooved in Portland Concrete surfaces and./or any markings as directed by the Engineer. The term long lines, when used in Items 642 through 648 includes edge lines, lane lines, center lines, and channelizing lines over 200 feet long. The term auxiliary markings, when used in Items 642 through 648 includes channelizing lines 200 feet or shorter, stop lines, yield lines, crosswalk lines, transverse lines, diagonal lines, curb markings, island markings, symbol markings, parking lot stall markings, lane arrows, and dotted lines.

641.09 Two-Way Radio Communications. If two-way radio equipment is required, furnish and maintain radio equipment necessary for the voice communication between the striper and the inspector's vehicle at all times during the pavement marking operation. Use equipment capable of transmitting and receiving normal voice communications to at least 4 miles.

641.10 Removal of Pavement Markings. If specified as a pay item, remove pavement markings as described in 614.11.G. Take care during marking removal not to scar, discolor, or otherwise damage the pavement surface. Do not overpaint or use other methods of covering markings instead of removal.

641.11 Deduction for Deficiency. For traffic paint and epoxy, the Engineer will compute each day the amount of marking material (including all components) and glass beads applied for each route section on the DLS report for determining unsatisfactory sections. The City will reduce the contract price for each route section in direct proportion to the percent of deficiency of marking material or glass beads as specified in 642.04, 646.05 and 648.05, up to 20 percent for each material deficiency. The City will only use the greater deficiency of marking material or glass beads to compute the deduction.

If the deficiency of marking material or glass beads is 20 percent or more, the City will consider the work unsatisfactory. In addition, the Engineer will consider as unsatisfactory materials applied outside the temperature or application requirements in Items 642, 646 and 648 without written approval of the Engineer. Replace pavement markings and glass beads in all sections determined to be unsatisfactory by retracing over the unsatisfactory markings at the full thickness specified in Items 642, 646 and 648.

641.12 Method of Measurement. The City will measure pavement markings complete in place in the units designated. The City will measure line quantities as the length of completed marking, including the gaps, intersections, and other sections of pavement not normally marked. The City will measure pavement markings removed by line quantities at the length of removed marking calculated using a 5 inch, 10 inch or 20 inch width including gaps, intersections, and other sections of pavement not normally marked. The City will measure the removal of all other pavement marking items by the number of items removed (each), or by the area of pavement markings removed (square foot).

641.13 Basis of Payment. The City will pay for accepted quantities of work performed under Items 642, 644, 645, 646, 647 and 648.

The City will not pay for costs associated with correcting improperly located lines, replacing reflectors coated with pavement marking material, or replacing unsatisfactory pavement markings.

The City will not pay for lines placed using non-specification materials.

The City will not pay for non-specification lines determined through field measurement.

The City will pay for Two-Way Radio Equipment at the lump sum bid price.

ITEM 642 TRAFFIC PAINT

642.01 Description
642.02 Materials
642.03 Equipment
642.04 Application
642.05 Basis of Payment

642.01 Description. This work consists of furnishing and applying fast dry water-based traffic paint or fast dry water-based traffic paint for cold weather applications according to Item 641, 740.01, 740.02, 740.09, and the additional requirements specified below.

642.02 Materials. Furnish materials conforming to:

Traffic Paint 740.02
Glass Beads, Type A 740.09

The Engineer may obtain random samples from the application equipment. Furnish the manufacturer's identification information for the sampled liquid materials. The City will test the quality assurance sample for conformance to the manufacturer's production ranges. For samples not meeting the manufacturer's production ranges, re-apply, at no cost to the City, any markings using that sample. The City will consider all other untested batches to be not approved materials and will either require testing or re-application.

Do not apply paints that have exceeded the manufacturer's shelf life. Do not use glass beads that are wet.

642.03 Equipment. Use equipment capable of applying the traffic paint as recommended by the manufacturer and applying glass beads at the time of line placement. Furnish a calibrated measuring device acceptable to the Engineer to measure the traffic paint in the striper tanks.

Equip all striping equipment for center line, lane line and edge line markings with a computerized Data Logging System (DLS) conforming to 641.04 when the length of marking exceeds 0.5 miles of continuous line equivalent.

Furnish written documentation to the Engineer for the equipment's operational capabilities from the equipment manufacturer.

642.04 Application. Apply pavement markings only when the surface is clean and dry in accordance with the paint manufacturer's written application instructions.

If application is required when air and pavement temperatures are between 35 °F and 50 °F obtain approval from the Engineer and apply only pre-qualified Type 1A cold weather traffic paint materials. Apply traffic paint according to the manufacturer's recommendations and protect line from tracking.

Keep the paint thoroughly mixed during application.

Apply 20 mil thick traffic paint Type 1 at the following rates:

20 Mil Thickness	Line Width (inch)				
	4	5	10	20	24
	Gallon per Mile of Line				
Solid Line	22	27.5	55	110	132
Broken Line	5.5	6.88	13.76	27.52	33
Dotted Line	5.5	6.88	13.76	27.52	33
Areas, Symbols, Words	1.25 gallon per 100 square feet				

Apply 15 mil thick traffic paint Type 1A at the following rates:

15 Mil Thickness	Line Width (inch)				
	4	5	10	20	24
	Gallon per Mile of Line				
Solid Line	16	20	40	80	96
Broken Line	4	5	10	20	24
Dotted Line	4	5	10	20	24
Areas, Symbols, Words	0.94 gallon per 100 square feet				

Do not dilute the paint. However, the Contractor may add spent traffic paint solvents, generated during performance of this work, to virgin traffic paint. If adding spent solvents, add them in a maximum ratio of 1:50 of spent solvents to virgin paint. Ensure that the maximum concentration of spent solvents in the striping equipment tanks is maximum 2 percent. Add spent solvents during the loading of the striping equipment.

Apply glass beads to the wet paint so that the beads are embedded and retained in the paint and provide uniform retroreflectivity in the paint surface. Apply glass beads at a minimum rate of 15 pounds per 100 square feet for Type 1 traffic paint. Apply glass beads at a minimum rate of 8.0 pounds per 100 square feet for Type 1A traffic paint.

Ensure temperature of the paint at the discharge point is within the range recommended by paint manufacturer.

Replace unsatisfactory markings according to 641.11.

Furnish the Engineer daily, biweekly and final DLS reports according to 641.04.

Perform traffic control operations for all Item 642 pavement markings according to 614.12 and MT-99.20, but provide for center line, edge line, lane line and channelizing line traffic control equipment according to MT-99.20 equipment requirements for center line, longer than 2 minute dry.

Include this work in the Item 642 price per mile for center line, edge line and lane line and the Item 642 price per foot for channelizing line.

642.05 Basis of Payment. The City will pay for accepted quantities at the contract prices, or prices adjusted according to 641.11, measured according to 641.12, with the provisions specified in 641.13, and as follows:

Item	Unit	Description
642	Mile	Edge Line, ___ inch, Type ___
642	Mile	Lane Line, ___ inch, Type ___
642	Mile	Center Line, Type ___
642	Foot	Channelizing Line, ___ inch, Type ___
642	Foot	Stop Line, Type ___
642	Foot	Yield Line, Type ___
642	Foot	Crosswalk Line, Type ___
642	Foot	Crosswalk Line Type II, Type ____
642	Foot	Transverse/Diagonal Line, Type ___
642	Foot	Curb Marking, Type ___
642	Square Foot	Island Marking, Type ___
642	Each	Handicap Symbol Marking, Type ___
642	Each	Railroad Symbol Marking, Type ___
642	Each	School Symbol Marking, ___ inch, Type ___
642	Each	Bicycle Lane Symbol Marking, Type ___
642	Each	Shared Lane Marking, Type ____
642	Foot	Parking Lot Stall Marking, Type ___
642	Each	Lane Arrow, Type ___
642	Each	Lane Drop Arrow
642	Each	Word on Pavement, ___ inch, Type ___
642	Foot	Dotted Line, ___ inch, Type ___
642	Each	Bike Marking, Type _____
642	Each	Speed Hump Marking, Type _____
642	Square Foot	Removal of Pavement Marking, or Each
642	Foot	Removal of Pavement Marking (___ inch)
642	Lump Sum	Two-Way Radio Equipment

ITEM 644 THERMOPLASTIC PAVEMENT MARKING

644.01 Description
644.02 Materials
644.03 Equipment
644.04 Application
644.05 Layout and Premarking
644.06 Basis of Payment

644.01 Description. This work consists of furnishing and applying screed extruded thermoplastic pavement markings according to Item 641, 740.01, 740.04, 740.09, and the additional requirements specified below.

644.02 Materials. Furnish materials from the City's QPL conforming to:

Thermoplastic pavement marking 740.04
Glass beads, Type C 740.09

The Engineer may obtain random samples from the application equipment. Furnish the manufacturer's identification information for the sampled liquid materials. The City will test the quality assurance sample for conformance to the manufacturer's production ranges. For samples not meeting the manufacturer's production ranges, re-apply, at no cost to the City, all markings using that sample. The City will consider all other untested batches to be not approved materials and will either require testing or re-application.

Do not apply material that has exceeded the manufacturer's shelf life. Do not use glass beads that are wet.

644.03 Equipment. Equip all thermoplastic pavement marking trucks for center line, lane line and edge line markings with a computerized Data Logging System (DLS), including a cab mounted display which shows the actual bead application rate. A DLS is not required for markings applied with hand carts. For center line, lane line and edge line markings applied with truck-mounted equipment, when the length of marking exceeds 0.5 miles of continuous line equivalent, document the following with the DLS:

1. Measure and record application vehicle speed to the nearest 0.1 MPH.
2. Measure and record pavement surface temperature.
3. Measure and record air temperature.
4. Measure and record thermoplastic temperature in the kettle and at the point of application.

Record as a separate DLS report line entry the above information for each route section painted, when the length of marking exceeds 0.5 miles of continuous line equivalent. A route section is defined as one direction of a contiguous section of highway (without breaks) with the same route number designation.

If the DLS equipment fails, finish that day's work only and resume when the DLS equipment is working.

Ensure that each DLS has an annual calibration of all mechanical and electrical components and its software function and output confirmed by the DLS manufacturer or their designated representative. Provide evidence of the annual calibration by affixing a signed and dated stamp or seal to the inside of the driver's door of each striper.

Use application equipment that includes a kettle for melting the thermoplastic and maintaining it at the proper temperature. Equip the kettle with a thermostat to control the temperature of the melted thermoplastic and to prevent overheating. Use equipment that continuously mixes and agitates the molten thermoplastic. Ensure that the parts of the equipment that convey the thermoplastic from the kettle to the application point maintains it at the required temperature.

Attach an automatic bead dispenser to the equipment so that the beads are immediately and uniformly dispensed over the marking surface. Equip the bead dispenser with an automatic cut-off control synchronized with the cut-off of the thermoplastic material.

Ensure that the applicator portion of the equipment has a shoe that rides on the pavement and extrudes the thermoplastic. Ensure that the application equipment applies lines with a square end and can apply broken lines. Furnish application equipment for applying extruded markings that consists of dies of varying widths to produce different widths of lines. Do not use pans, aprons, or similar devices that the die overruns.

Use equipment that ensures uniformity in the thickness and width of lines. Use equipment that forms lines 12 inches wide or less by one application pass, and lines wider than 12 inches by no more than two passes. Do not allow individual passes to overlap or to be separated by a gap greater than 1/4 inch.

644.04 Application. If applying thermoplastic to pavements that are less than six months old, ensure that both the pavement surface and the ambient air temperature at the time of application are not less than 50 °F and rising. However, if applying thermoplastic to pavements that are older than six months, ensure that both the pavement surface and the ambient air temperature at the time of application are not less than 60 °F and rising. Ensure that the temperature of thermoplastic at the point of application is at least 400 °F and not more than 440 °F.

Apply thermoplastic at a thickness of 125 mils. Thermoplastic for small quantities or auxiliary markings up to 100 feet in length can be exchanged as equal in function and price with 125 mil thick heat-fused preformed thermoplastic (Item 647).

Apply thermoplastic at the following rates:

125 Mil Thickness	**Line Width (inch)**				
	4	**5**	**10**	**20**	**24**
	Pounds per Mile of Line				
Solid Line	2340	2925	5850	11700	14040
Broken Line	585	731	1462	2925	3510
Dotted Line	585	731	1462	2925	3510
Areas, Symbols, Words	133 pounds per 100 square feet				

Mechanically apply glass beads to the wet thermoplastic surface so that the beads are embedded and retained and provide uniform retroreflectivity in the surface. Do not place beads by hand, except to symbols and words, and to complete the ends of lines. Apply beads at a minimum rate of 12 pounds per 100 square feet of thermoplastic surface area.

When placing Item 644 on concrete pavement or concrete bridge decks, furnish primer, and apply it according to the manufacturer's recommendations. Include primer cost in the unit price. Use primer except on new asphalt pavement.

For each route section on the DLS report, the Engineer will compute the amount of thermoplastic marking material and glass beads applied. The City will reduce the contract price in direct proportion to the percent of deficiency of thermoplastic marking material or glass beads as specified in 644.04, up to 20 percent for each material deficiency. The City will only use the greater deficiency of marking material or glass beads to compute the deduction.

If the deficiency of thermoplastic marking material or glass beads is 20 percent or more, the City will consider the work unsatisfactory. In addition, the Engineer will consider as unsatisfactory materials applied outside the temperature or application requirements in 644.04 without written approval of the Engineer. Replace thermoplastic markings and glass beads in all sections determined to be unsatisfactory by entirely removing the unsatisfactory thermoplastic material by grinding according to 641.10 and then reapplying at the full thickness specified in 644.04. Do not apply a layer of sprayed thermoplastic to sections determined to be unsatisfactory to achieve the required thickness.

Furnish the Engineer daily, biweekly and final DLS reports conforming to 644.03, and additional reports indicating material type and quantities in pounds of thermoplastic materials used, according to 641.04.

644.05 Layout and Premarking. In addition to the requirements specified in 641.06, only place auxiliary markings on new pavement. The Contractor may place initial thermoplastic markings over work zone traffic paint markings.

644.06 Basis of Payment. The City will not pay for any thermoplastic lines that do not meet the required thickness. The City will pay for accepted quantities at the contract prices, or prices adjusted according to 644.04, measured according to 641.12, with the provisions specified in 641.13, and as follows:

Item	Unit	Description
644	Mile	Edge Line, ___ inch
644	Mile	Lane Line, ___ inch
644	Mile	Center Line
644	Foot	Channelizing Line, ___ inch
644	Foot	Stop Line
644	Foot	Crosswalk Line
644	Foot	Transverse/Diagonal Line
644	Each	Handicap Symbol Marking
644	Each	Railroad Symbol Marking, ___ inch
644	Each	School Symbol Marking, __ inch
644	Foot	Parking Lot Stall Marking
644	Each	Lane Arrow
644	Each	Lane Drop Arrow
644	Each	Word on Pavement, ___ inch
644	Foot	Dotted Line, ___ inch
644	Each	Bike Marking
644	Each	Speed Hump Marking, Type
644	Lump Sum	Two-Way Radio Equipment

ITEM 645 PREFORMED PAVEMENT MARKING

645.01 Description
645.02 Materials
645.03 Application
645.04 Layout and Premarking
645.05 Basis of Payment

645.01 Description. This work consists of furnishing and applying preformed pavement marking material according to Item 641, 740.01, 740.05, 740.06, and the additional requirements specified below.

645.02 Materials. Furnish materials from the City's QPL conforming to the following:

Type A (permanent markings),
Type A1, A2, or A3 ..... 740.05
Type B (work zone markings),
Type II (non-removable) 740.06
Type C (work zone markings),
Type I (removable) 740.06

Do not apply materials that have exceeded the manufacturer's shelf life.

645.03 Application. Only apply on clean dry pavement surfaces. If there is oil, salt or dust; power wash the pavement and allow the pavement to dry.

Furnish the Engineer with the manufacturer's application instructions. Record the surface temperature and date of application. Furnish documentation to the Engineer. Apply preformed markings to the pavement by means of a precoated adhesive on the back, or by an adhesive or activator furnished with the markings and used according to the manufacturer's recommendations. Form lines 12 inches wide or less by one piece; form lines wider than 12 inches (by no more than two pieces. Do not overlap individual pieces. Do not allow a gap greater than ¼ inch between pieces.

Do not use preformed markings that are subject to premature adhesion or contamination before placement.

Apply preformed markings according to the appropriate type of application as follows:

A. Type A Marking Application. Apply the preformed markings while the pavement surface temperature is at the manufacturer's application recommendations. Before any application, test and record the pavement surface temperature, air temperature and dew point. Retest and record every 4 hours of operation. Demonstrate to the Engineer the testing devices are accurate and operational. Initially position the marking under light pressure, or use a hand operated light roller or mechanical applicator. Once correctly located, hold the marking in position without delay by rolling.

If Type A preformed markings are specified to be inlaid on newly placed asphalt concrete, press the markings into the warm surface using a mechanical roller. Proper application of inlaid markings requires that the asphalt concrete pavement surface have a temperature below the maximum temperature recommended for the preformed material or its adhesive backing.

If Type A preformed markings with contrast are specified to be placed on Portland Cement Concrete using grooved construction, adhere to Standard Drawing 1645 which shows the installation of the pavement marking material in a groove, parallel at a concrete joint, and crossing a concrete joint, as well as the manufacturers' recommendations and the following application requirements.

1. Groove Specifications.

All weather and climate conditions for the specific pavement marking product must be met before application into the groove.

a. Groove Width – Longitudinal Markings: Extra care must be taken to cut straight grooves that will allow for a straight alignment of the pavement marking installed in the groove.

b. Groove Position: Curb and median obstacles may not allow for cutting the groove using large truck mounted equipment. Use smaller equipment in areas near obstacles to achieve a groove at the recommended depth.

c. Groove Cutting Speed: The speed of groove cutting equipment will vary with the width of the groove, the size of the application, the pavement surface, and the equipment and blades used for cutting. The speed must be set in accordance with other factors to ensure the required groove depth specifications are met.

d. Grooved Cleaning: Cooling the cutting head with water may be necessary for some applications and equipment. In general, long continuous groove cuts for edge lines may require water to keep the blades cool. If cooling water is necessary, flush the groove immediately with a high-pressure power washer to remove any build-up of cement dust/water slurry to prevent slurry hardening in the groove. Groove cutting for skip dash or other intermittent markings may not require cooling water since the blades cool between cutting operations.

Allow the groove to dry a minimum of 24 hours after groove cleaning and removal of excess water. Clean the groove completely using an air blower (high pressure or utility blower). The groove must be clean and dry for proper application of the pavement marking.

See Table 645.03-1 for lines that require grooving applications and contrast markings.

TABLE 645.03-1 GROOVED PRE-FORMED MARKING MATERIAL

Description	Legend	Unit	(2) Contrast
Channelizing Line, 10"	CH	LF	Y
Lane Line, Dashed, 5"	LL	MILE	Y
Lane Line, Solid, 5"	LS	MILE	Y
Lane Line, Solid Double, 5"	LD	MILE	Y
Edge Line, White, 5"	WE	MILE	Y
Edge Line, White, 10"	WE10	MILE	Y
5" Dotted Line White- 2' with 6' spacing	WD	LF	Y
10" Dotted Line White- 2' with 6' spacing	WDW	LF	Y
5" Dotted Line White- 3' with 9' spacing	WDL	LF	Y
10" Dotted Line White- 3' with 9' spacing	WDWL	LF	Y
Center Line, Dashed Yellow, 5"	CD	MILE	N
Center Line, Double Yellow, 5"	DY	MILE	N
Center Line, Solid/Dashed Yellow, 5"	CSD	MILE	N
5" Dotted Line Yellow- 2' with 6' spacing	YD	LF	N
10" Dotted Line Yellow- 2' with 6' spacing	DYD	LF	N
5" Dotted Line Yellow- 3' with 9' spacing	YDL	LF	N
10" Dotted Line Yellow- 3' with 9' spacing	DYDL	LF	N
Bike Lane			
5" Bike Lane Solid	BL	MILE	Y
10" Bike Lane Solid	CBL	MILE	Y
5" Bike Lane Dashed	BLD	MILE	Y
10" Bike Lane Dashed	CBLD	MILE	Y

2. Surface Texture Requirements:

Groove equipment with free-floating, independent cutting or grinding head shall be used.

A textured groove surface that has an irregular pattern and does not show the typical ribbed or corduroy pattern is required for this application. Besides using a grinder cutting head, a textured groove surface can also be achieved with the saw blade configuration using a slow moving shot blaster, grinder, or sand blaster to knock down the ridges and create a textured surface after cutting the initial groove with the saw blade cutting head. Hydro blasting can also be used, but the groove must be allowed a minimum of 24 hours to dry prior to application of the pavement markings. The Contractor shall follow dust control requirements found in Item 616 Dust Control.

Auxiliary pavement markings shall not be grooved.

3. Measuring Uniform Groove Depths:

A micrometer or depth gauge shall be used to verify the uniform depth of new grooves. Grooves should be checked frequently as a new alignment is cut to make adjustments early in the process. Calculate an average of the 5 depths measured. The average shall equal the appropriate depth shown in Standard Drawing 1645. If the average does not equal the values shown, make adjustments to the cutting equipment until the depth shown in Standard Drawing 1645 is the average calculated groove depth.

B. Type B and Type C Marking Application. Apply the preformed markings according to the manufacturer's recommendations.

645.04 Layout and Premarking. In addition to the requirements specified in 641.06, place preformed auxiliary markings only on new pavement.

645.05 Basis of Payment. The City will not pay for under thickness lines or non-specification materials. The City will pay for accepted quantities at the contract prices, or prices adjusted according to 641.11, measured according to 641.12, with the provisions specified in 641.13, and as follows:

Item	Unit	Description
645	Mile	Edge Line, Type ___, with Contrast
645	Mile	Edge Line, Type ___, without Contrast
645	Mile	Edge Line, Grooved, with Contrast
645	Mile	Edge Line, Grooved, without Contrast
645	Mile	Lane Line, Type ___, with Contrast
645	Mile	Lane Line, Type ___, without Contrast
645	Mile	Lane Line, Grooved, with Contrast
645	Mile	Center Line, Type ___
645	Mile	Center Line, Grooved
645	Foot	Channelizing Line, Type ___, with Contrast
645	Foot	Channelizing Line, Type ___, without Contrast
645	Foot	Channelizing Line, Grooved, with Contrast
645	Foot	Stop Line, Type ___
645	Foot	Crosswalk Line, Type ___
645	Foot	Transverse/Diagonal Line, Type ___
645	Each	Handicap Symbol Marking, Type ___
645	Each	Railroad Symbol Marking, Type ___
645	Each	School Symbol Marking, ___ inch, Type ___
645	Foot	Parking Lot Stall Marking, Type ___
645	Each	Lane Arrow, Type ___
645	Each	Lane Drop Arrow, Type ____
645	Each	Word on Pavement, ___ inch, Type ___
645	Foot	Dotted Line, Type ___, with Contrast
645	Foot	Dotted Line, Type ___, without Contrast
645	Foot	Dotted Line, Grooved, with Contrast
645	Foot	Dotted Line, Grooved, without Contrast
645	Each	Bike Marking
645	Each	Speed Hump Marking
645	Lump Sum	Two-Way Radio Equipment
645	Foot	Bike Lane Line, Type ___, with Contrast
645	Foot	Bike Lane Line, Type ___, without Contrast
645	Foot	Bike Lane Line, Grooved, with Contrast

ITEM 646 EPOXY PAVEMENT MARKING

646.01 Description
646.02 Materials
646.03 Equipment
646.04 Cleaning and Surface Preparation
646.05 Application
646.07 Basis of Payment

646.01 Description. This work consists of furnishing and applying epoxy pavement markings according to Item 641, 740.01, 740.07, 740.09, and the additional requirements specified below.

Store and handle epoxy material according to all the applicable EPA and local environmental regulations and the manufacturer's recommendations.

646.02 Materials. Furnish materials from the City's QPL conforming to:

Epoxy pavement markings 740.07

Glass beads, Type D..... 740.09

The Engineer may obtain random samples from the application equipment.

Furnish the manufacturer's identification information for the sampled liquid materials. The City will test the quality assurance sample for conformance to the manufacturer's production ranges. For samples not meeting the manufacturer's production ranges, re-apply, at no cost to the City, any markings using that sample. The City will consider all other untested batches to be not approved materials and will either require testing or re-application.

Do not apply material that has exceeded the manufacturer's shelf life. Do not use glass beads that are wet.

646.03 Equipment.

A. General. Equip all striping equipment for center line, lane line and edge line markings with a computerized Data Logging System (DLS) conforming to 641.04 when the length of marking exceeds 0.5 miles of continuous line equivalent.

Furnish written documentation to the Engineer for the equipment's operational capabilities from the equipment manufacturer.

Use equipment to apply epoxy pavement markings that has the following capabilities and features:

1. Capable of mixing the epoxy components in proportions recommended by the manufacturer and applying glass beads simultaneously with line placement.
2. Capable of applying epoxy at the specified thickness, width, and pattern.
3. Individual material reservoirs, or space, for the storage of Part A and Part B of the epoxy.
4. Heating equipment of sufficient capacity to maintain the epoxy components at the manufacturer's recommended temperature, and to produce the required amount of heat at the mixing head and gun tip and maintain those temperatures with the tolerances recommended by the epoxy manufacturer for the spray application.
5. Adequate individual tanks for the storage and dispensing of Size I and Size II glass beads.
6. Individual dispensers for the simultaneous application of Size I and Size II glass beads at specified rates.
7. Individual metering devices on the proportioning pumps (one indicator per pump) and stroke counters to monitor gallon usage. Ensure that these devices are clearly visible.
8. All the necessary spray equipment mixers, compressors, and other appurtenances to allow for the placement of reflectorized pavement marking systems in a simultaneous sequence of operations.
9. A minimum 24-inch long static mixer unit or an equivalent system that produces properly mixed material.
10. A completely enclosed flush and purge system to clean the lines and the guns without expelling any of the solution into the environment.

B. Long Line Equipment. Furnish a striper to apply long line epoxy markings that is:

1. Truck-mounted and self-contained.
2. Designed to spray the epoxy and glass beads in continuous and skip line.
3. Maneuverable to the extent that straight lines can be followed and normal curves can be made in a true arc.

C. Auxiliary Marking Equipment. Furnish application equipment for auxiliary markings by either of the following two methods:

1. Equip the striper with accessories for applying auxiliary markings.
2. Use a portable applicator approved by the Engineer.

D. Documentation Requirements. Furnish the Engineer documentation from the manufacturer that the equipment meets all requirements of 646.03. Demonstrate the equipment has the capability to obtain the manufacturer's required temperature for the mixed components and the required temperature at the lines and gun.

646.04 Cleaning and Surface Preparation.

A. General. Before applying epoxy, clean and prepare the pavement surface in the following sequence:

1. Remove all debris, oil, and any other contaminants that may hinder the adhesion of the epoxy to the pavement.
2. Use a power-broom to clean the pavement.
3. Remove residue and debris with blasts of compressed air.
4. Follow any additional manufacturer's recommendations for surface preparation.

Perform operations in such a manner that the finished pavement surface is not damaged or unnecessarily scarred or left in a pattern that will mislead or misdirect the motorist and that minimizes airborne dust. Avoid damage to transverse and longitudinal joint sealers.

B. Asphalt Concrete Pavements. In addition to the requirements of 646.04.A, the following apply.

Wait 48 hours after the placement of polymer modified asphalt-concrete pavement before preparing it for epoxy pavement markings.

For any other type of modified asphalt or for open graded friction course asphalts, contact the manufacturer for surface preparation recommendations. Furnish the Engineer copies of the manufacturer's recommendations.

Lightly abrade any new asphalt concrete pavement containing SBS, SBR latex or SMA latex polymer modifiers without scarring the area between the broken lines to the manufacturer's recommendations to remove polymer surface film to ensure proper bonding. In no case shall the removal of the polymer surface film be less than that required for the epoxy to properly bond and adhere.

C. Portland Cement Concrete Pavements. On new portland cement concrete pavements, do not begin cleaning operations until a minimum of 30 days after the placement of concrete, unless otherwise directed by the Engineer. In addition to the requirements of 646.04.A, the following apply.

Remove all curing compound and laitance on the concrete surface and in any textured pavement valleys.

Round the profiles of the peaks of textured pavement and remove sharp edges and irregularities.

Acceptable removal methods are:

1. Sand blasting with containment.
2. Lightly abrading the surface without scarring the surrounding surface. This must be demonstrated before the application and approved by the Engineer.
3. Blast track cleaning.
4. High-pressure water blasting (greater than 5000 psi) with or without abrasives and with sufficient time to allow the pavement to dry before applying epoxy markings.
5. Other methods approved by the Engineer.

Contain and dispose of all the removal debris.

D. Removal of Existing Markings. When placing epoxy markings in the same place as existing pavement markings, remove at least 95 percent of the existing pavement markings. Use a removal method that results in little or no color and texture changes in the surrounding pavement.

E. Preparation Area.

1. Lines. Prepare an area that is the width of the new pavement marking, or existing line, plus 1-inch on each side and the length of broken lines plus 12 inches on each end.

2. Arrows, Letters, and Symbols. When cleaning for letters and symbols, prepare an area that is sufficiently large to accommodate the new marking, or to remove the existing marking.

646.05 Application. Apply epoxy only when the surface is clean and dry and when the pavement and air temperature are above 50 ºF. Transfer the entire contents of each material container to the striper tanks. Keep the epoxy thoroughly mixed at all times during application. Before any application, test and record the pavement surface temperature, air temperature. Retest and record every 4 hours of operation. Demonstrate to the Engineer the testing devices including DLS are accurate and operational.

Apply epoxy uniformly to the surface to be marked at a rate specified below. To achieve the rate, ensure that the thickness of the applied epoxy is 20 mils.

20 Mil Thickness	**Line Width (inch)**				
	4	**5**	**10**	**20**	**24**
	Gallon per Mile of Line				
Solid Line	22	27.5	55	110	132
Broken Line	5.5	6.88	13.75	27.5	33
Dotted Line	5.5	6.88	13.75	27.5	33
Areas, Symbols, Words	1.25 gallon per 100 square feet				

Do not dilute the epoxy.

Apply enough glass beads to the uncured epoxy so that the beads completely fill the epoxy film from the film-pavement interface to the top surface of the film to the extent that there are loose beads on the surface of the uncured line. Apply glass beads at a minimum rate of 31 pounds per 100 square feet of epoxy to achieve uniform retroreflectivity. Drop glass beads onto the epoxy in a double-drop system with the large gradation (Size I) first and the regular gradation (Size II) second in the same pass of the equipment. Apply the beads in equal amounts by weight.

Cease operations when any of the following conditions are observed:

A. The marking does not consistently dry to a no-track condition.

B. The marking has cyclical soft spots.

Resume marking operations when the Engineer is satisfied the problem is corrected.

Replace unsatisfactory markings according to 641.11.

Furnish the Engineer daily, biweekly and final DLS reports according to 641.04.

646.07 Basis of Payment. The cost of cleaning and surface preparation according to 646.04 is included in the unit bid cost for the various pavement markings.

The City will pay for accepted quantities at the contract prices, or prices adjusted according to 641.11, measured according to 641.12, with the provisions specified in 641.13, and as follows:

Item	Unit	Description
646	Mile	Edge Line, ___ inch
646	Mile	Lane Line, ___ inch
646	Mile	Center Line
646	Foot	Channelizing Line, ___ inch
646	Foot	Stop Line
646	Foot	Yield Line
646	Foot	Crosswalk Line
646	Foot	Transverse/Diagonal Line
646	Foot	Curb Marking
646	Square Foot	Island Marking
646	Each	Handicap Symbol Marking
646	Each	Railroad Symbol Marking
646	Each	School Symbol Marking, ___ inch
646	Foot	Parking Lot Stall Marking
646	Each	Lane Arrow
646	Each	Lane Drop Arrow
646	Each	Word on Pavement, ___ inch
646	Foot	Dotted Line, ___ inch
646	Each	Bike Marking
646	Each	Speed Hump Marking
646	Lump Sum	Two-Way Radio Equipment

ITEM 647 HEAT-FUSED PREFORMED THERMOPLASTIC PAVEMENT MARKING

647.01 Description
647.02 Materials
647.03 Equipment
647.04 Application
647.05 Basis of Payment

647.01 Description. This work consists of furnishing and applying heat-fused preformed thermoplastic for use as auxiliary pavement markings according to Item 641, 740.01, 740.08 and the additional requirements specified below.

647.02 Materials. Furnish materials from the City's QPL conforming to:

Heat fused preformed thermoplastic
pavement marking material 740.08

647.03 Equipment. Use manufacturer recommended equipment to apply the heat-fused preformed thermoplastic pavement marking material according to the appropriate type, as follows:

A. Not Used.

B. Type B90 or Type B125 Material.

1. Propane torch for ensuring no moisture is present on the pavement and heating the material according to 647.04.C.
2. A thermometer is not required.

647.04 Application.

A. General. Apply the heat-fused preformed thermoplastic pavement marking material to clean, dry pavement surfaces according to the appropriate type unless otherwise directed by the manufacturer's recommendation. Apply primer sealer on portland cement concrete pavements for proper adhesion only if the manufacturer requires its use.

Form lines 12 inches wide or less by one piece; form lines wider than 12 inches by no more than two pieces. Do not overlap individual pieces. Do not allow a gap greater than 1/4-inch between pieces.

B. Not Used.

C. Type B90 and Type B125 Material Application on Asphalt Concrete and Portland Cement Concrete Pavements. Heat the pavement only to ensure no moisture is present. Place the material on the dry surface and then uniformly heat the material until it bubbles and changes color to off-white. Ensure material can be applied with no preheating of the pavement to a specified temperature and without the use of a thermometer. Allow the material to cool naturally and solidify before exposing it to traffic.

Type B90 and B125 material shall contain intermix glass beads throughout. Drop-on glass beads are not required unless using a non-surface beaded marking (i.e., for turn or combination arrows).

647.05 Basis of Payment. The City will pay for accepted quantities at the contract prices, or prices adjusted according to 641.11, measured according to 641.12, with the provisions specified in 641.13, and as follows:

Item	Unit	Description
647	Foot	Channelizing Line, Type ___ with Contrast
647	Foot	Channelizing Line, Type ___ without Contrast
647	Foot	Stop Line, Type ___
647	Foot	Yield Line, Type____
647	Foot	Crosswalk Line, Type ___
647	Foot	Crosswalk Line Type II, Type ____
647	Foot	Transverse/Diagonal Line, Type ____
647	Each	Handicap Symbol Marking, Type ___
647	Each	Railroad Symbol Marking, Type ___
647	Each	School Symbol Marking, ___ inch, Type ___
647	Each	Bicycle Lane Symbol Marking, Type____
647	Each	Bicycle Detector Marking, Type ___
647	Square Foot	Bike Lane Markings, (Green), Type ___
647	Each	Bike Boulevard Marking, One Way, Type ___
647	Each	Bike Boulevard Marking, Two Way, Type ___
647	Each	Shared Lane Marking, Type ___
647	Foot	Parking Lot Stall Marking, Type ___
647	Each	Lane Arrow, Type ___
647	Each	Lane Drop Arrow
647	Each	Word on a Pavement, ___ inch, Type ___
647	Each	Bike Marking, Type _____
647	Each	Speed Hump Marking, Type _____
647	Foot	Dotted Line, Type ___, with Contrast
647	Foot	Dotted Line, Type ___, without Contrast
647	Foot	Center Line, Type ___
647	Foot	Edge Line, Type ___, with Contrast
647	Foot	Edge Line, Type ___, without Contrast
647	Foot	Lane Line, Type ___, with Contrast
647	Foot	Lane Line, Type ___, without Contrast
647	Foot	Bike Lane Line, Type ___, with Contrast
647	Foot	Bike Lane Line, Type ___, without Contrast

ITEM 648 SPRAY THERMOPLASTIC PAVEMENT MARKING

648.01 Description
648.02 Materials
648.03 Equipment
648.04 Surface Preparation
648.05 Application
648.06 Basis of Payment

648.01 Description. This work consists of furnishing and applying spray thermoplastic pavement markings according to Item 641, 740.01, 740.09, 740.10, and the additional requirements specified below.

648.02 Materials. Furnish materials from the City's QPL conforming to:

Spray Thermoplastic Pavement Marking 740.10
Glass beads, Type C..... 740.09

The Engineer may obtain random samples from the application equipment. Furnish the manufacturer's identification information for the sampled materials. The City will test the quality assurance sample for conformance to the manufacturer's production ranges. For samples not meeting the manufacturer's production ranges, re-apply, at no cost to the City, any markings using that sample. The City will consider all other untested batches to be not approved materials and will either require testing or re-application.

Do not apply material that has exceeded the manufacturer's shelf life. Do not use glass beads that are wet.

648.03 Equipment. Provide spray thermoplastic pavement marking equipment and documentation as required in 644.03.

Ensure that the application equipment applies lines with a square end and can apply broken lines. Furnish application equipment for applying spray thermoplastic markings that produces different widths of lines.

Use equipment that ensures uniformity in the thickness and width of lines. Use equipment that forms lines 10 inches wide or less by one application pass.

648.04 Surface Preparation. Before applying spray thermoplastic the pavement surfaces must be clean, dust free, and completely dry. Test for moisture using the following test procedures, if needed as directed by the Engineer:

Moisture Test

1. Tape a 12 inch square sheet of thin plastic to the road surface, sealing all edges.
2. After 15 minutes examine the side of the sheet facing the road surface.
3. If more than a sparse amount of moisture is present, do not apply spray thermoplastic.

Apply spray thermoplastic to new pavement, over existing thermoplastic, or over one application of paint. Do not apply spray thermoplastic over epoxy or preformed markings. Remove poorly adhering, flaking and loose markings and curing compounds. Use an air blast, or manual or mechanical broom to prepare surfaces. When more effort is needed to obtain a surface free from adhering, flaking and loose markings and curing compounds, use water blasting or mechanical removal.

648.05 Application. If applying spray thermoplastic to pavements that are less than six months old, ensure that both the pavement surface and the ambient air temperature at the time of application are not less than 50 °F and rising. However, if applying spray thermoplastic to pavements that are older than six months, ensure that both the pavement surface and the ambient air temperature at the time of application are not less than 60 °F and rising. Ensure that the temperature of spray thermoplastic at the point of application is at least 375 °F and not more than 440 °F.

Apply spray thermoplastic at a thickness of 45 mil at the following rates:

45Mil Thickness	**Line Width (inch)**			
	4	**5**	**8**	**10**
	Pounds per Mile of Line			
Solid Line	762-886	952.5-1107.5	1524-1772	1905-2215
Broken or Dotted Line	191-222	477-554	381-443	477-554

Mechanically apply glass beads to the wet spray thermoplastic surface so that the beads are embedded and retained and provide uniform retroreflectivity in the surface. Apply beads at a minimum rate of 10 pounds per 100 square feet of spray thermoplastic surface area.

Use primer when required by the manufacturer. Apply primer according to the manufacturer's recommendations.

For each route section on the DLS report, the Engineer will compute the amount of spray thermoplastic marking material and glass beads applied. The City will reduce the contract price in direct proportion to the percent of deficiency of spray thermoplastic marking material or glass beads as specified in 648.05, up to 20 percent for each material deficiency. The City will only use the greater deficiency of marking material or glass beads to compute the deduction.

If the deficiency of spray thermoplastic marking material or glass beads is 20 percent or more, the City will consider the work unsatisfactory. In addition, the Engineer will consider as unsatisfactory materials applied outside the temperature or application requirements in 648.05 without written approval of the Engineer. Replace or reapply spray thermoplastic markings and glass beads in all sections determined to be unsatisfactory as determined by the Engineer.

Furnish the Engineer daily, biweekly and final DLS reports conforming to 648.03, and additional reports indicating material type and quantities in pounds of spray thermoplastic materials used, according to 641.04.

648.06 Basis of Payment. The City will not pay for any spray thermoplastic lines that do not meet the required thickness. The City will pay for accepted quantities at the contract prices, or prices adjusted according to 648.05, measured according to 641.12, with the provisions specified in 641.13, and as follows:

Item	**Unit**	**Description**
648	Mile	Edge Line, ___ inch
648	Mile	Lane Line, ___ inch
648	Mile	Center Line
648	Foot	Channelizing Line, ___ inch
648	Foot	Dotted Line, ___ inch
648	Lump Sum	Two-Way Radio Equipment

650 ROADSIDES

ITEM 651 TOPSOIL STOCKPILED

651.01 Description
651.02 Construction Requirements
651.03 Method of Measurement
651.04 Basis of Payment

651.01 Description. This work consists of stripping topsoil from areas shown on the plans or from within the Right-of-Way limits, transporting, and stockpiling topsoil at locations shown on the plans or at locations selected by the Contractor with the Engineer's approval.

651.02 Construction Requirements. Remove all heavy grass, weeds, or other vegetation over selected areas before stripping. Keep the topsoil separate from other excavated materials. Remove topsoil before beginning the regular excavation or embankment work in the area. Strip the topsoil to the depth shown on the plans or as directed by the Engineer.

651.03 Method of Measurement. The City will measure Topsoil Stockpiled by the number of cubic yards completed and accepted, measured from the removal areas.

651.04 Basis of Payment. The City will not pay for any removal of topsoil beyond the directed depth.

The City will pay for accepted quantities at the contract price as follows:

Item	Unit	Description
651	Cubic Yard	Topsoil Stockpiled

ITEM 652 PLACING STOCKPILED TOPSOIL

652.01 Description
652.02 Construction Requirements
652.03 Method of Measurement
652.04 Basis of Payment

652.01 Description. This work consists of hauling and spreading topsoil from stockpiles and preparing the surface.

652.02 Construction Requirements. Prepare the surface according to 659.10. Place and spread the topsoil according to 659.11.

652.03 Method of Measurement. The City will measure Placing Stockpiled Topsoil by the number of cubic yards completed and accepted in place.

652.04 Basis of Payment. The City will pay for accepted quantities at the contract price as follows:

Item	Unit	Description
652	Cubic Yard	Placing Stockpiled Topsoil

ITEM 653 TOPSOIL FURNISHED AND PLACED

653.01 Description
653.02 Materials
653.03 Construction Requirements
653.04 Method of Measurement
653.05 Basis of Payment

653.01 Description. This work consists of furnishing and spreading topsoil and preparing the subgrade.

653.02 Materials. Furnish topsoil consisting of loose, friable, loamy material without admixture of subsoil, stone or refuse. For topsoil to be considered loamy, ensure that the fraction passing the No. 10 sieve does not contain more than 40 percent clay. Furnish topsoil consisting of not less than 4 percent and not more than 20 percent organic matter as determined by loss on ignition of samples oven dried to constant weight at 212 °F. Test topsoil according to AASHTO T 267. Furnish topsoil that is free of grass, brush, rocks and roots.

653.03 Construction Requirements. Before placing any topsoil, prepare all areas to be covered with topsoil according to 659.10. Place the topsoil according to 659.11. When seeding is specified, open the topsoil up to receive the seed.

653.04 Method of Measurement. The City will measure compacted Topsoil Furnished and Placed by the number of calculated cubic yards accepted in place.

653.05 Basis of Payment. The City will pay for accepted quantities at the contract price as follows:

Item	Unit	Description
653	Cubic Yard	Topsoil Furnished and Placed

ITEM 654 RENOVATING EXISTING SOIL

654.01 Description
654.02 Materials
654.03 Construction Requirements
654.04 Method of Measurement
654.05 Basis of Payment

654.01 Description. This work consists of preparing a suitable seedbed by grading and renovating existing soil and stone; and furnishing and placing commercial fertilizer, if specified.

Use removed or excavated materials in the Work when the material conforms to the specifications; if not, then recycle or dispose of the material according to 105.16 and 105.19.

654.02 Materials. Use commercial fertilizer conforming to 659.04 or compost conforming to 659.06.

654.03 Construction Requirements. Prepare the surface area for seed according to 659.10.

If the Contract Documents require commercial fertilizer, place it according to 659.04.

654.04 Method of Measurement. The City will measure Renovating Existing Soil by the number of M square feet completed and accepted.

The City will measure Commercial Fertilizer by the number of tons completed and accepted.

654.05 Basis of Payment. The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
654	M Square Feet	Renovating Existing Soil
654	Ton	Commercial Fertilizer
654	Cubic Yard	Compost

ITEM 655 TREE PROTECTION

655.01 Description
655.02 General
655.03 Root Zone
655.04 Fencing
655.05 Necessary Tree Removal
655.06 Method of Measurement
655.07 Basis of Payment

655.01 Description. This work consists of tree protection against injury, damage or removal to branches, trunks or roots from construction and excavation. No unspecified tree or branch shall be removed without approval from the City Forester.

655.02 General. Perform all work in accordance with the requirements of the City of Columbus, Forestry Section. All tree pruning and removal must be done in accordance with Item 666. The Contractor performing the work must be a professional tree care company with a certified arborist on staff and available to direct the onsite crew.

655.03 Root Zone. Perform all work in such a way as to protect the root zone of all existing trees not specified for removal. Construction materials, excavation debris, chemicals, fuel, fire, equipment, and vehicles are not permitted to be stockpiled, stored, dumped or parked within the dripline of any tree.

Heavy equipment will not be allowed to compact the soil over the root zone of existing trees. Restricted equipment access routes will be established prior to any work beginning. Temporary paving materials, such as plywood, lumber or rubber matting, may be required to prevent compaction.

Installation of utilities under the dripline of existing trees must be directionally bored or drilled below the root zone. The top of the bore or tunnel should be no larger than 3 feet deep. Open trenches within the root zone must be avoided.

Where grade change is required within the root zone, a sufficient residual root zone must remain undisturbed to provide for the good health of the trees. Protect the residual root zone by either a dry well or retaining wall if the grade is to be raised or lowered.

655.04 Fencing. Protect all existing trees designated for preservation with a good, substantial fence, frame or box. The barrier protection must be a minimum of 4 feet in height and, if possible, constructed along the dripline or further from the tree. If it is not possible to construct the fencing at the dripline or further, the location will be approved by the Engineer based on site limitations.

Fencing must be installed prior to commencing site preparation work. The fence must be maintained throughout the duration of the project.

655.05 Necessary Tree Removal. The Contractor is responsible for the protection of all trees. All trees and branches interfering with the work shall not be injured, damaged, or removed without approval from the Engineer. When removal is acceptable, remove and prune in accordance with these standards.

All branches or growth from trees that are to be saved and which are interfering with the work may be removed by the use of pruning tools. All pruning tools and methods employed shall in accordance to Item 666.

If tree trimming is required, a permit must be acquired from the City Forester at the Department of Recreation and Parks. No construction shall take place within 10 feet of a tree without prior approval of the City Forester.

655.06 Method of Measurement. The City will measure the cost of all work associated with tree protection against injury or damage by the Lump Sum.

The City will measure the cost of all work and expenses associated with the removal of trees and/or branches in accordance with Item 201, Clearing and Grubbing.

Any trees damaged or destroyed due to Contractor negligence will be treated or removed at the Contractor's expense. If damaged beyond repair, the City will require reimbursement for the value of the tree as determined by the current edition of the "Guide for Plant Appraisal".

655.07 Basis of Payment.

The City will pay for accepted quantities at the contract price for as follows:

Item	Unit	Description
655	Lump Sum	Tree Protection during Construction

ITEM 657 RIPRAP FOR TREE PROTECTION

657.01 Description
657.02 Materials
657.03 Tree Wells in Fill
657.04 Tree Wells in Cut
657.05 Hand-Laid Stone Riprap
657.06 Earthwork
657.07 Not Used
657.08 Method of Measurement
657.09 Basis of Payment

657.01 Description. This work consists of furnishing and placing riprap for protecting selected trees or shrubs from construction by installing tree wells and retaining walls. All work shall comply with ANSI Standard A300-*Tree, Shrub, and Other Woody Plant Maintenance-Standard Practices*, Part 5-*Management of Trees and Shrubs during Site Planning, Site Development, and Construction*; and its companion publication *Best Management Practices: Managing Trees during Construction*.

657.02 Materials. Furnish stone consisting of sandstone, limestone, or other natural rock complying with the requirements of 703.19.B. Use an 8-inch slab test sample. The City may waive testing when the stone source has a known durability history. Furnish embankment according to Item 203. Unless otherwise specified, use 4-inch pipe conforming to Item 603 Type E conduits.

657.03 Tree Wells in Fill. Where fill around a tree or shrub noted for protection will be required within the tree or shrub critical root zone (CRZ), construct a dry hand-laid stone riprap retaining wall to the diameter shown on plans or details. Construct a wall, of the same height as the fill, circling the tree or shrub at the greatest distance from the trunk to the drip line as shown on plans and standard details. Construct the wall so that the top of the wall follows the contour on the finished grade in a neat line. Flare the ends of the wall back and taper or fade them out into the finished grade of the slope in a neat line.

657.04 Tree Wells in Cut. Where the City requires a cut around a tree or shrub marked for protection, within the tree or shrubs critical root zone (CRZ), construct a dry hand-laid stone riprap retaining wall. Toe the bottom of the wall into the ground 2 inches unless otherwise shown on the plans. Construct a wall, of the same height as the fill, circling the tree or shrub at the greatest distance from the trunk to the drip line. Construct the wall so that the top of the wall matches the original grade. Flare the ends of the wall back and taper or fade them out into the finished grade of the slope in a neat line.

657.05 Hand-Laid Stone Riprap. Construct the earth bed on which riprap is to be placed to a slope of 1 foot vertical to 2 inches horizontal. Dress the earth bed to a true plane. Where riprap is to rest against a fill, tamp the embankment against the back of the stone.

Construct riprap for walls or wells according to the arrangements and dimensions shown on the plans. Lay each course with the long dimensions of each stone perpendicular to the slope or batter.

Use individual stones that are roughly rectangular in cross-section and are a minimum of 3 inches in the vertical depth with a horizontal dimension of not less than 15 inches. Place the individual stones by hand, one upon the other so that they break joints with the stone in the course below. Where it is necessary to use more than one stone to provide the specified thickness or depth of the wall, thereby resulting in joints parallel to the face of the wall, place such stones to break joints with the adjacent stones.

Fill the space between the larger stones with spalls rammed into place. Ensure that the surface of the finished riprap does not vary more than 3 inches from that shown on the plans, and that it presents an even, tight surface, pleasing in appearance.

657.06 Earthwork. Perform excavation and embankment, as necessary, according to Item 203.

657.07 Not Used.

657.08 Method of Measurement. The City will measure Riprap for Tree Protection by the number of square yards in place, completed and accepted. The City will measure parallel to the face of the wells or walls.

657.09 Basis of Payment. The City will pay for accepted quantities at the contract price for as follows:

Item	Unit	Description
657	Square Yard	Riprap for Tree Protection

ITEM 659 SEEDING AND MULCHING

659.01 Description
659.02 Testing of Soil or Topsoil
659.03 Lime
659.04 Commercial Fertilizer
659.05 Topsoil
659.06 Compost
659.07 Seeds
659.08 Legumes
659.09 Native Grasses and Wildflowers
659.10 Site Preparation
659.11 Placing Topsoil
659.12 Seeding Methods
659.13 Mulching Operation
659.14 Straw Mulch
659.15 Wood Fiber Mulch
659.16 Compost Mulch
659.17 Watering
659.18 Maintenance
659.19 Mowing
659.20 Repair Seeding and Mulching
659.21 Inter-Seeding
659.22 Fertilization: 2nd Application
659.23 Performance
659.24 Method of Measurement
659.25 Basis of Payment

659.01 Description. This work consists of placing topsoil; preparing the seed bed; placing and incorporating seed, agricultural lime, commercial fertilizer; and placing mulching material used to achieve NPDES final stabilization.

Perform this work in areas shown on the plans for seeding and mulching.

Perform seeding and mulching after completing all work in the area and within 7 days of obtaining final grade. If it is anticipated that future work may disturb an area, place temporary NPDES compliant Best Management Practices as needed until final stabilization measures under this item can be installed. If the Contractor disturbs a final area, then the Contractor shall restore this area. With the Engineer's approval, the Contractor may apply permanent seed between October 30 and March 1 on projects started and completed within the same calendar year.

Use all excavation material in the work. Alternatively legally use, recycle, or dispose of all excavated materials according to 105.16 and 105.19.

659.02 Testing of Soil or Topsoil. When a Soil Analysis Test of the soil or topsoil is required in the plans, use the following sampling frequency to determine the lime required:

A. When an area is near final grade, perform Standard Soil Analysis Test to measure the soil acidity or alkalinity (pH) if no topsoil is to be placed. This testing will determine the soil requirements for lime. If the soil requirements are different than the standard lime mixture ratio application rates, then the standard application rate shall be adjusted up or down such that the soil requirements are met. If liquid lime is used then use the following application table to achieve a pH of 6.5 or greater. Calculate the difference between the soil pH and 6.5 pH.

pH Difference	0.25	0.50	0.75	1.0
Application rate in gals/ac	2.5	5	10	20
Example: Soil Analysis Test pH=5.75 required pH=6.5 difference=0.75 required application rate is 10 gals/ac				

Only use liquid lime on ODOT's QPL list. Provide the Engineer with the liquid lime manufacturers written application rate. The Engineer will only accept printed application rates.

There will be no change in the mixture ratio. The sampling frequency is one sample every 10 acres per project side or one sample per project side whichever is greater. Samples consist of 15 soil cores in a random pattern spaced at a minimum of 500 feet apart. Sample any change in soil. Soil changes can be seen as color and/or texture changes.

B. If placing topsoil, perform the Standard Soil Analysis Test from topsoil stockpiles to measure the topsoil acidity or alkalinity (pH). This testing will determine the soil requirements for lime. If the topsoil requirements are different than the standard lime mixture ratio application rates, the standard application rate shall be adjusted up or down such that the topsoil requirements are met.

If liquid lime is used then use the following application table to achieve a pH of 6.5 or greater. Calculate the difference between the soil pH and 6.5 pH.

pH Difference	0.25	0.50	0.75	1.0
Application rate in gals/ac	2.5	5	10	20
Example: Soil Analysis Test pH=5.75 required pH=6.5 difference=0.75 required application rate is 10 gals/ac				

Only use liquid lime on the ODOT QPL. Provide the Engineer with the liquid lime manufacturers written application rate. The Engineer will only accept printed application rates.

There will be no change in the mixture ratio. The sampling frequency is one sample every 10,000 cubic yards of a topsoil stockpile, or at least two samples per stock pile whichever is greater. Test each stockpile. A sample consisting of 15 soil cores in a random pattern spaced evenly throughout the stockpile.

Mix the 15 cores from each sample and then remove 1 pint for testing.

The Ohio County Extension offices can provide the Contractor with a soil sample kit and testing laboratory locations.

The City will review the sample test results and approve application rates for the standard mixture ratios provided by the Contractor.

If a Soil Analysis Test of the soil is not required by the plans, use the standard application rates for lime and commercial fertilizer.

659.03 Lime. Obtain granular or liquid lime from an agricultural lime dealer or manufacturer whose brands are grades registered or licensed by the State of Ohio, Department of Agriculture. The granular or liquid lime standard grade is Ag-ground 90+. Ag-ground 90+ is defined as agricultural ground limestone, having a total neutralizing power (TNP) of 90 percent or more, at least 40 percent passing a No. 100 sieve and 95 percent passing a No. 8 sieve. Test granular or liquid lime according to ODOT Supplement 1007. Apply the granular or liquid lime standard grade Ag-ground 90+ at the standard application rate of 92 pounds per 1000 square feet (2 tons per acre).

The Contractor may provide other lime grade materials. The lime grade materials provided will meet Table 7-10 "Equivalent Amounts of Liming Materials" found in Bulletin 472, *Ohio Agronomy Guide*, published by the Cooperative Extension Service, The Ohio State University. Based on the type of lime grade material provided, determine the increase or decrease in the standard application rate from Table 7-10 "Equivalent Amounts of Liming Materials" found in Bulletin 472, "Ohio Agronomy Guide", published by the Cooperative Extension Service, The Ohio State University.

If using liquid lime, apply liquid lime at a rate of 5 gals/acre unless otherwise required per the soil or topsoil Soil Analysis Test. Provide the Engineer with the liquid lime manufacturers written application rate. The Engineer will only accept printed application rates. Only use liquid lime on the ODOT QPL.

If testing of the soil or topsoil was performed, use sufficient lime to reach a slightly acidic (pH 6.5) growing environment. Adjust the application rate of the standard grade lime Ag-ground 90+ up or down to achieve this condition and report to the City for approval. No lime is required for the soil or topsoil if the test shows a slightly acidic condition.

659.04 Commercial Fertilizer. Obtain commercial fertilizer from a dealer or manufacturer whose brands are grades registered or licensed by the State of Ohio, Department of Agriculture.

Use dry or liquid commercial fertilizer. Apply standard commercial fertilizer 10-20-10 evenly over the surface at a standard dry application rate of 20 pounds per 1,000 square feet. Furnish liquid application rates for approval by the City.

The Contractor may provide other commercial fertilizer mixture ratios, however, ensure that the ratio meets or exceeds the standard commercial fertilizer ratio of 10-20-10 by providing an application rate specific for that ratio. The City will approve this application rate that is specific to that ratio provided by the Contractor.

For areas of inter-seeding apply commercial fertilizer 12-12-12 over the affected area at the above rate.

For commercial fertilizer second application the method, mixture, and rate is broadcast 12-12-12 evenly over the surface without incorporation into the soil at a rate of 10 pounds per 1,000 square feet.

659.05 Topsoil. If placing topsoil as specified in the plan, then stockpile topsoil off site for testing and/or stockpile stripped topsoil from the project for testing. Perform the Soil Analysis Test from these stockpiles to determine the percent of organic matter present. Ensure that the topsoil conforms to 653.02. Test topsoil according to AASHTO T 267.

The City will review the sample test results and approve the stockpiles for use. Do not use stockpiles outside the above limits.

Use stripped topsoil from the R/W limits from the upper most layers of the excavation areas. Remove all heavy grass, weeds, and other vegetation before stripping topsoil from the excavation areas.

The City will treat a mixture of 1 part compost and 2 parts topsoil as topsoil.

659.06 Compost. Acceptable compost includes Ohio EPA rated Class IV compost, EQS biosolids compost, or a City approved equal. Furnish compost with a nitrogen content of 1.4 percent or above. Obtain compost from an Ohio EPA approved facility. Before delivering compost, provide the Engineer with the facility name and location.

659.07 Seeds. Furnish grass seed from a grass seed dealer or grower whose brands are grades registered or licensed by the State of Ohio, Department of Agriculture or from the approved list of grass seed mixes approved by the Ohio Department of Transportation per ODOT Supplement 1022. Furnish the kind and type of grass seed required that meets current specifications on file with ODOT as to percentage purity, percentage weed seed, and percentage germination.

Mark the test date on seed bags. Furnish seeds as separate species and cultivars, packaged together or bagged separately, and labeled, tagged, or marked according to ORC 907.03. Sow seeds within 9 months of the testing date. The City reserves the right to test, reject, or approve all seed after delivery.

659.08 Legumes. Inoculate or treat all leguminous seeds (crown vetch) with the proper amount of pure nitrogen-fixing bacteria and mix with sufficient water to thoroughly wet the seed. Select bacteria for maximum vitality no more than one-year old. Provide all culture records with the leguminous seeds.

If sown hydraulically, use 4 times the inoculant rate specified by the inoculant manufacturer. If pre-inoculated seed is used then use 3 times the inoculant rate specified by the inoculant manufacturer. Immediately before seeding, add inoculant and sticking agent directly into the slurry, and thoroughly mix the slurry. Sow seed as soon as possible after inoculation. If left standing for more than 24 hours, inoculate seed before sowing. Mix all seed on the project. Sixty days before seeding, provide a written description for the Class 3C mixture showing the percentage by weight of each kind of seed for the Engineer's approval.

Include the following with the description:

A. Name and location of the seed supplier.

B. Origin and date of harvest of each kind of seed.

C. A statement of the purity and germination of each type of seed.

D. Testing date for each seed.

E. How and when seeds were mixed.

659.09 Native Grasses and Wildflowers. Table 659.09-1 lists the seed quantities by weight per area. Use Classes 4, 5, and 6 in the amounts of pure live seed (PLS) for each species listed. If seed tests show that the seed has an actual pure live seed (PLS) yield less than the intended yield, adjust the specified quantity to provide the intended PLS yields.

For Class 4, 5, and 6 mixtures, provide seed specifically grown for the Ohio climate.

Use cool season turf Classes 1, 2, 3A, and 3B as listed in Table 659.09-1 composed of no less than two and no more than four cultivars of the same species. Sixty days before seeding, provide a written description for the Class 1, 2, and 3A mixtures showing the percentage by weight of each kind of seed for the Engineer's approval. Mix all seed on the project. Sixty days before seeding, provide a written description for the Classes 1, 2, 3A, 3B, 4, 5, and 6 mixtures showing the percentage by weight of each kind of seed for the Engineer's approval.

Include the following with the description:

A. Name and location of the seed supplier.

B. Origin and date of harvest of each kind of seed.

C. A statement of the purity and germination of each seed.

D. Testing date for each seed.

E. How and when seeds were mixed.

TABLE 659.09-1 GRASS AND WILDFLOWER SEED MIXES

Class	Mix Type Seeds	Weight per Area lb 1000 ft^2
1	Lawn Mixture Use for areas in front of residences, commercial properties, etc. between curb and sidewalk with slopes 3:1 or flatter.	
	Kentucky Bluegrass (Poa pratensis)	2
	Tall Fescue, Turf Type (Festuca arundinacea)	6
	Perennial Ryegrass, Turf Type (Lolium perenne)	2
	Application rate based on % by weight provided.	
	Seed shall be: Poa Annua, Bent Grass, Kentucky-31, Alta Varietes, and noxious weed free.	
2	Roadside Mixture	
	Kentucky Bluegrass (Poa pratensis)	1.5
	Kentucky 31 Fescue (Festuca arundinacea var. KY 31)	2
	Perennial Ryegrass (Lolium perenne)	1.5

3A	Slope Mixtures Use for slopes flatter than or equal to 3:1.	
	Use Class 2, 3B, 3C, or 4B mixtures	
3B	Low Growing Slope Mixture Use for slopes steeper than 3:1 when low growing species are required.	
	Hard Fescue (Festuca longifolia)	1.3
	Creeping Red Fescue (Festuca rubra)	0.8
	Annual Ryegrass (Lolium multiflorum)	0.23
3C	American Vetch Mixture Use for slopes steeper than 3:1 and shale or rock slopes.	
	American Vetch (Vicia Americana)	0.9
	Perennial Ryegrass (Lolium perenne)	1.8
	Annual Ryegrass (Lolium multiflorum)	0.3
4A	Native Grass Mixture Use for slopes flatter than 2:1 and seeding for wildlife habitat mitigation.	
	Big Bluestem (Andropogon gerardii)	0.07
	Indiangrass (Sorghastrum nutans)	0.09
	Switchgrass (Panicum virgatum)	0.02
	Annual Ryegrass (Lolium multiflorum) spring fall	0.11 0.34
4B	Low Growing Native Grass Mixture Use for slopes flatter than 2:1 and seeding for wildlife habitat mitigation when low growing species are required.	
	Little Bluestem (Schizachyrium scoparium)	0.18
	Sideoats Grama (Bouteloua curtipendula)	0.04
	Prairie Dropseed (Sporobolus heterolepis)	0.04
	Annual Ryegrass (Lolium multiflorum) spring fall	0.11 0.34
5A	Annual and Perennial Wildflower Mixture Use for slopes flatter than 2:1 and seeding for wildlife habitat mitigation.	
	Annual Mixture Do not exceed 25% by weight of any one of the following species:	0.07
	Corn Poppy (Papaver rhoeas)	
	Cosmos (Cosmos bipinnatus)	
	Yellow Cosmos (Cosmos sulphureus)	
	Cornflower (Centaurea cyanus)	
	Rocket Larkspur (Delphinium ajacis)	
	Indian Blanket (Gaillardia pulchella)	
	Perennial Wildflower Mixture Do not exceed 50% by weight PLS of any one of the following species:	0.28
	Black-eyed Susan (Rudbekia hirta)	
	Purple Coneflower (Echinacea purpurea)	
	Lance-leaved Coreopsis (Coreopsis lanceolata)	
5B	Native Wildflower and Grass Mixture Use for slopes flatter than 2:1 and seeding for wildlife habitat mitigation.	
	Native Wildflower Mixture Do not exceed 10% by weight PLS of any one of the following species:	0.34
	Butterfly-weed (Asclepias tuberosa)	
	New England Aster (Aster novae-angliae)	
	Partridge Pea (Cassia fasciculata)	
	Purple Coneflower (Echinacea purpurea)	
	Rattlesnake Master (Eryngium yuccifolium)	
	Ox-eye Sunflower (Heliopsis helianthoides)	
	Wild Bergamot (Monarda fistulosa)	
	Greyhead Coneflower (Ratibida pinnata)	
	Orange Coneflower (Rudbekia fulgida)	
	Prairie Dock (Silphium terebinthinaceum)	
	Whorled Rosinweed (Silphium trifoliatum)	

	Stiff Goldenrod (Solidago rigida)	
	Grass Mixture	
	Big Bluestem (Andropogon gerardii)	0.046
	Little Bluestem (Schizachyrium scoparium)	0.069
	Indiangrass (Sorghastrum nutans)	0.023
	Annual Ryegrass (Lolium multiflorum)	0.92
6	Wildlife Mixture Use for slopes flatter than 2:1 and seeding for wildlife habitat mitigation.	
	Big Bluestem (Andropogon gerardii)	0.13
	Little Bluestem (Schizachyrium scoparium)	0.18
	Indiangrass (Sorghastrum nutans)	0.13
	Ox-eye Sunflower (Heliopsis helianthoides)	0.18
	Prairie Dock (Silphium terebinthinaceum)	0.18
	Purple Coneflower (Echinacea purpurea)	0.18
	Whorled Rosinweed (Silphium trifoliatum)	0.11
	Downy Sunflower (Helianthus mollis)	0.07
	New England Aster (Aster novae-angliae)	0.07
	Annual Ryegrass (Lolium multiflorum) spring fall	0.11 0.34
7	Temporary Erosion Control Mixture	
	Annual Ryegrass (Lolium multiflorum)	2.02

659.10 Site Preparation. Before placing topsoil or seed remove rock or other foreign material of 1 inch or greater in any dimension from all areas.

Finish the area in such a manner that seeding, place sod, planting, or, placing topsoil can proceed without additional soil preparation.

Apply commercial fertilizer, lime, or other soil amendments including compost to the soil or topsoil surface in separate operations. Incorporate the commercial fertilizer, granular lime, or other soil amendments, including compost either separately or together, into the soil or topsoil to a depth of 2 to 4 inches. Do not mix Liquid lime into the soil or topsoil. Only apply liquid lime to the top of the soil or topsoil. Furnish a smooth surface for the seed or topsoil by tracking with a dozer or by other methods. If the site is inaccessible to a dozer and other methods do not provide results equivalent to hand raking, hand rake these areas. Provide a uniform surface, free of gullies, rivulets, crusting, and caking. Finely grade the surface for seed or topsoil for slopes 4:1 or flatter, and grade all other slopes. Rake or open the surface with a dozer cleats or otherwise loosen the surface of these areas to a depth of 1 inch immediately before covering with topsoil. Remove raked up material from the area.

659.11 Placing Topsoil. If shown on the plans, place topsoil in loose lifts that construct a 4-inch compacted depth. The surface of the topsoil shall be such that the final grade as shown on the cross-sections is met. Use the following methods or combination of any of the methods to produce the required space to place the topsoil.

A. Item 203 can be cut or placed to the final grade, which will match the plan quantities for Item 203, and then remove a 4-inch thickness for the topsoil.

B. Item 203 can be cut or placed to a 4-inch height below the final grade. There will be no change from the plan quantities in Item 203 for this method.

Track the area with a dozer to compact and provide good contact between the topsoil and the surface. Create track marks parallel with the centerline of the roadway.

The Contractor may place topsoil by using pneumatic, or hydraulic methods. If using pneumatic or hydraulic methods to place the topsoil, the Contractor may place the top 1-inch with a mix of seed, commercial fertilizer, lime, and other soils amendments. This mixture will be 1 part compost and 2 parts topsoil. Do not apply mulch to this surface. The compost is the mulch.

659.12 Seeding Methods. Apply seed to prepared areas. If the prepared areas to be seeded become compacted before seeding, loosen the surface using disks, rakes, or other methods.

Thoroughly mix all seed, and evenly sow the seed over the prepared areas at the required rates. Do not sow seed during high winds. For slopes subject to windy conditions, seed using hydraulic methods only. Operate equipment in a manner to ensure complete coverage of the entire area to be seeded.

TABLE 659.12-1 SEEDING REQUIREMENTS

Classes	March 1 to May 31	June 1 to August 15	August 16 to August 31	September 1 to October 30	October 31 to February 28
1	Yes [2] [3]	Yes [2] [3]	Yes [1] [3]	Yes [1] [3]	No [5]
2	Yes [2] [3]	Yes [2] [3]	Yes [1] [3]	Yes [1] [3]	No [5]
3A	Yes [2] [3]	Yes [2] [3]	Yes [1] [3]	Yes [1] [3]	No [5]

3B	Yes [2] [3]	Yes [2] [3]	Yes [1] [3]	Yes [1] [3]	No [5]
3C	Yes [3]	Yes [3]	Yes [3]	No	No [5]
4	Yes	No	No	Yes	No [5]
5	No [6]	No	No	Yes	No [5]
6	No [6]	No	No	Yes	No [5]
7	Yes [3]	Yes [3]	Yes [3]	Yes [3]	Yes [4]

[1] Contractor may broadcast seed Classes 1, 2, 3A, and 3B between August 15 to October 30.
[2] If necessary to seed Classes 1, 2, 3A, or 3B before August 15, but after March 1 increase the seeding rates by 5 percent.
[3] Between March 1 and October 30, the Contractor may use hydro seeding, which applies the mulch, seed, water, and commercial fertilizer in the same operation, for Classes 1, 2, 3A, 3B, 3C, and 7.
[4] Between October 30 and March 1, apply temporary seed according to NPDES requirements.
[5] With the Engineer's approval, the Contractor may apply permanent seed between October 30 and March 1 on projects started and completed within the same calendar year.
[6] Between March 1 and May 31, the contractor may apply Wildflower Class 5 and 6 seed if permitted by the Engineer.

Seed before or concurrently with all required erosion control items.

Seed native grasses and wildflowers in Classes 4, 5, and 6 with a rangeland type, slit seeder or native seed grass drill. Seed native grasses with no less than two passes in different directions and by equally splitting the seed application rate to each pass. Use broadcast seeding, along with cultipacking or rolling, only with the Engineer's approval.

If broadcast seeding, perform the following, immediately after sowing, to provide good seed-soil contact:

A. For flat surfaces, lightly rake the area then roll.

B. For slopes, track the area with a dozer.

659.13 Mulching Operation. Mulch materials consist of straw, compost, or wood fiber. Provide wood fiber mulch when Class 1 seed is specified in the plans. Use mulch reasonably free of weed seed, foreign materials, or other materials that would prohibit seed germination. Do not mulch during high winds. For slopes subject to windy conditions mulch using hydraulic methods only. Within 24 hours after seeding an area, evenly place mulch. Immediately replace mulch that becomes displaced.

659.14 Straw Mulch. Straw mulch consists of straw. Straw mulch is permitted for use in Class 2-7 seeding areas. Evenly place straw mulch over all seeded areas at the following rates:

Seeding Period	Rate
From March 15 to October 30	2 tons per acre
From October 31 to March 14	3 tons per acre

Keep straw mulching materials in place by applying an asphalt emulsion at a minimum rate of 60 gallons per ton of straw mulch or by applying tackifiers according to the manufacturer's recommendations. Apply an additional application at a rate of 30 gallons per ton of straw mulch to shoulder areas, starting at the berm edge and extending out for a distance of 10 feet. Use an emulsion that is nontoxic to plants and prepared in a manner that will not change during transportation or storage.

659.15 Wood Fiber Mulch. Wood Fiber mulch is permitted for use in Class 1-7 seeding areas. Wood fiber mulch consists of pure wood fibers manufactured expressly from clean wood chips. Ensure that the chips do not contain lead paint, varnish, printing ink, and petroleum based compounds. Do not use wood fiber mulch manufactured from recycled materials of unknown origin such as sawdust, paper, cardboard, or residue from chlorine-bleached pulp and paper mills.

Ensure that the wood fiber mulch maintains uniform suspension in water under agitation and blends with grass seed, commercial fertilizer, and other additives to form a homogeneous slurry. Use manufacturer-approved tackifiers.

Using standard hydraulic mulching equipment, evenly apply the slurry over the soil surface in a one-step operation. Apply slurry from March 1 to October 30 at the following rates:

Surface	Rate
Slopes 3:1 or flatter	46 pounds per 1000 square feet

659.16 Compost Mulch. Compost mulch is permitted for use in Class 1-7 seeding areas. Provide compost applied to a minimum depth of 1/4-inch over the prepared seed areas. Mix the grass seed with the compost and using pneumatic equipment. Place this mixture to a minimum depth of 1/4-inch over the prepared seed areas. If using compost, the City will not require tackifiers or asphalt emulsion.

659.17 Watering. Thoroughly water all permanent seeded areas (Classes 1 to 6) after the seed germinates. As a primary water application, apply a total rate of 300 gallons per 1,000 square feet in at least 2 applications spread over 7 days. Apply the water using a hydro-seeder or a water tank under pressure with a nozzle that produces a spray does not dislodge the mulch material.

Perform a secondary water application between 7 and 10 days after the primary applications. If 1/2-inch or greater of rain falls within the first 7-day period, delay or omit the secondary application, depending on weather conditions. If 1/2–inch or less of rain fall is received on the project site, repeat the primary water application process.

659.18 Maintenance. Maintain all seeded and mulched areas until final inspection. Repair damaged areas to the original condition and grade.

659.19 Mowing. The Engineer may require mowing before permanent seeding and during the growing season following permanent seeding. The Engineer will notify the Contractor of when to begin each mowing. Use suitable mowing equipment of the rotary, flail, disk, or sickle type. Use handheld equipment where inaccessible by larger equipment. Do not bunch or windrow mowed vegetation. Mow to a final cutting height of no less than 6 inches. If necessary to achieve the cutting height, make more than one pass with the mower.

659.20 Repair Seeding and Mulching. Repair all damage or erosion of the seeded and mulched areas before the completion of the project.

Rework or reshape slopes, and bring in additional material, as necessary, using whatever equipment is necessary to restore slopes to grade. Seed and mulch repaired areas according to this specification. As an alternative, apply compost to repair areas as specified in Item 659.

659.21 Inter-Seeding. Inter-seeding is defined as seeding existing thin and spotty growing turf using a slit or drill type seeder. Perform inter-seeding only from March 15 to May 15 and from September 1 to October 15. If necessary to achieve good seed-soil contact, mow before seeding according to Item 659.

For seeding steep slopes or inaccessible areas, use broadcast or hydraulic seeding methods. Broadcast commercial fertilizer over affected areas as specified in Item 659. Water affected areas at the rate specified in Item 659 to aid in seed-soil contact.

659.22 Fertilization: 2nd Application. After completion of all repair seeding and mulching, and inter-seeding, and no earlier than 3 months after seeding, perform a Soil Analysis Test if shown on the plans to determine the need for a second application of commercial fertilizer. Do not apply the second application of commercial fertilizer unless the grass has germinated. Broadcast commercial fertilizer of 12-12-12 evenly over the surface without incorporation at a rate of 10 pounds per 1000 square feet.

659.23 Performance. The City will inspect all seeded areas no earlier than 6 months and no later than 12 months after final seeding. For any area identified without a uniform density of at least 70 percent grass cover, repair seeding and mulching as specified in Item 659 or perform inter-seeding as specified in Item 659, and fertilize as specified in this subsection.

Also repair seeding and mulching or perform inter-seeding, and fertilize seeded areas damaged by traffic or erosion, due to no fault or negligence of the Contractor.

659.24 Method of Measurement. The City will measure Soil Analysis Test by the number of tests submitted to the Engineer.

The City will measure the compacted topsoil by the number of cubic yards.

The City will measure Commercial Fertilizer by the number of tons of each quantity of furnished, spread, and incorporated into the soil or topsoil. The City will convert this measure to the standard application rate for the standard mixture ratio.

The City will measure lime or liquid lime by the number of acres furnished, spread, and incorporated into the soil or topsoil. The City will convert the measure to the standard application rate for the standard mixture ratio.

The City will measure Seeding and Mulching by the number of square yards.

The City will measure Repair Seeding and Mulching by the number of square yards of damaged or eroded areas reshaped, seeded, and mulched. If the Contractor substitutes compost for mulch to repair areas, the City will include such work under Repair Seeding and Mulching.

The City will measure Water by the number of M gallons or 1000 gallon units applied. The City will measure water in tanks, tank wagons, or trucks of predetermined capacity, or by means of meters of a type satisfactory to the Engineer and furnished and installed by the Contractor at expense to the City, or determined by weight conversion.

The City will measure Inter-Seeding by the number of square yards of the seeded area.

The City will measure mowing by the number of M square feet satisfactorily mowed.

If seeded areas are damaged by traffic or erosion, due to no fault or negligence of the Contractor, the City will measure for such work and mobilization in accordance with 109.05.

The City will not measure for repairs to seeding and mulching if damage or erosion of the areas occurs as a result of fault or negligence of the Contractor.

659.25 Basis of Payment. The City will pay the plan quantity for compacted topsoil. The City will not adjust topsoil quantities when the volume between two consecutive cross-sections differs by less than 5 percent from the plan quantity, unless the difference between the actual quantity and plan quantity is greater than 1000 cubic yards. For quantity differences greater than 5 percent or greater than 1000 cubic yards, submit supporting documentation to the Engineer.

The City will pay the plan quantity for Seeding and Mulching. The City will not adjust Seeding and Mulching quantities when the area between two consecutive cross-sections differs by less than 5 percent from the plan quantity, unless the difference between the actual quantity and plan quantity is greater than 20,000 square yards for all Seeding and Mulching pay items, combined. For quantity differences greater than 5 percent or greater than 20,000 square yards, submit supporting documentation to the Engineer.

The City will pay for accepted quantities at the contract prices as follows (M=1000):

Item	Unit	Description
659	Each	Soil Analysis Test
659	Cubic Yard	Topsoil
659	Ton	Commercial Fertilizer
659	Acres	Lime
659	Square Yard	Seeding and Mulching for Wildlife
659	Square Yard	Seeding and Mulching, Class ___
659	Square Yard	Repair Seeding and Mulching
659	M Gallons	Water
659	Square Yard	Inter-Seeding
659	M Square Feet	Mowing

ITEM 660 SODDING

660.01 Description
660.02 Materials
660.03 Lifting Sod
660.04 Preparation of Areas to be Sodded
660.05 Placing Sod on Slopes 3 to 1 or Flatter
660.06 Placing Sod on Slopes Steeper than 3 to 1 but Flatter than 2 to 1
660.07 Placing Sod in Ditches
660.08 Placing Reinforced Sod on Slopes 2 to 1 or Steeper
660.09 Watering
660.10 Method of Measurement
660.11 Basis of Payment

660.01 Description. This work consists of furnishing, hauling, excavating for and preparing the bed, and placing sod.

660.02 Materials. Furnish sod consisting of well-rooted Kentucky Blue Grass (Poa pratensis) or Turf Type tall fescue (Festuca arundinacea) per the plan. Provide sodding containing a growth of not more than 30 percent of other grasses and clovers, and free from all noxious weeds such as wild mustard, thistles, quack grass, and Johnson grass, and reasonably free from dandelions and crab grass.

Provide certification by the sod supplier that the sod certified by complies with Item 660. Provide sod mowed to a height of not more than 3 inches. Furnish a certificate with each shipment, and furnish the following additional information from the sod supplier:

A. The name of the producer.

B. The amount of sod shipped in square yards.

C. The location of sod field.

D. The location of job site.

E. The sod cut date.

F. The sod cut thickness.

Furnish wood stakes no less than 1/2 × 3/4 × 12 inches.

Furnish 18-inch long T-pins ¼ inch in diameter with a 3-inch tee.

Furnish 18-inch long round pins ¼ inch in diameter with a 1.5-inch washer.

Furnish galvanized poultry netting 50 inches wide with 2-inch mesh and No. 20 gage minimum wire.

Furnish fertilizer and lime according to Item 659.

660.03 Lifting Sod. Furnish sod strips that are not less than 3 feet and not over 6 feet in length with a uniform width of not over 24 inches. Furnish sod strips that lay flat on skids. The Contractor may elect to deliver sod rolls of up to 25 feet in length. Furnish pre-rolled sod rolls on skids. Furnish sod cut to a depth equal to the growth of the fibrous roots but in no case less than 1 inch.

Deliver sod to the job within 24 hours after cutting, and install it within 48 hours after cutting.

During wet weather, allow the sod to dry sufficiently to prevent tearing during handling and placing. During dry weather, water the sod before lifting to ensure its vitality and to prevent the dropping off of the soil in handling.

660.04 Preparation of Areas to be Sodded. Before placing the sod, excavate the sod bed to a depth that when the sod is in place the top of the sod is flush with the surrounding grade and conforms to the typical cross-section. If specified, place the topsoil according to Item 659. If specified under Item 659, apply commercial fertilizer and agricultural liming material. Incorporate these materials in the areas to be sodded at the rate specified in 659.03 and 659.04 to a depth of not less than 1 inch. Incorporate these materials within 48 hours prior to placing the sod. Immediately before placing the sod, rake the area or otherwise bring it to an even surface forming a proper sod bed. If the area is dry, thoroughly water the sod bed.

660.05 Placing Sod on Slopes 3 to 1 or Flatter. Do not place any sod when the temperature is below 32 °F. Do not place any frozen sod, and do not place any sod upon frozen soil. When placing sod between June 1 and October 15, cover it immediately with straw mulch 1 inch thick, loose measurement.

Lift sod from trucks or storage piles, and place it by hand with close joints and no overlapping. Plug all gaps between sections of sod and openings at angles with sod. After laying, thoroughly water the sod, and tamp the sod with approved sod tampers sufficiently to bring the sod into close contact with the sod-bed and to ensure tight joints between the sections or strips. Upon placing the sod, ensure that the surface of the sodded areas coincides with the finished grade.

660.06 Placing Sod on Slopes Steeper than 3 to 1 but Flatter than 2 to 1. Place sod on slopes steeper than 3 to 1 but flatter than 2 to 1 according to 660.05, with the following modifications.

Lay sod with the long edges of the strip parallel to the contour starting at the bottom of the slope. Neatly match successive strips, and stagger all joints by at least 12 inches.

For sod placed 6 feet or greater in height (measured along the slope), stake each strip or roll securely along all sides with stakes not more than 2 feet apart with the flat side against the slope or with pins not more than 2 feet apart. Drive the wooden stakes so that the last 1 inch remains above the top of the sod. Drive pins 1 inch below the top of the grass.

After laying, thoroughly water the sod, and tamp the sod with approved tampers sufficiently to bring the sod into close contact with the sod-bed and to ensure tight joints between the sections or strips.

660.07 Placing Sod in Ditches. Place sod in ditches according to 660.05, with the following modifications.

Place sod in ditches with joints staggered at least 12 inches. Stake each strip or roll securely along all sides with wooden stakes not more than 2 feet apart with the flat side against the slope. Drive the wooden stakes so that the last 1 inch remains above the top of the sod.

660.08 Placing Reinforced Sod On Slopes 2 to 1 or Steeper. Place reinforced sod on slopes 2 to 1 or steeper or as specified in the plans according to 660.05, with the following modifications. Before placing the sod, place the galvanized poultry netting or equivalent. Stake the galvanized poultry netting or equivalent securely to the subgrade by using pins or wood stakes. Place the pins or wooden stakes at 4 foot intervals. Fasten the netting to the wooden stakes with staples. Where the sod width is from 8 to 10 feet wide, the Engineer will allow two strands of netting for a total width of 8 feet. For sod, stake each strip or roll securely along all sides with wooden stakes not more than 2 feet apart with the flat side against the slope or with pins not more than 2 feet apart. Drive the wooden stakes so that the last 1 inch remains above the top of the sod. Drive pins 1 inch below the top of the grass.

660.09 Watering. Keep all sodded areas thoroughly moist for 45 days after sodding. Repair any areas damaged following installation. Ensure that sod is in place for at least 45 days before final acceptance.

660.10 Method of Measurement. The City will measure Sodding Unstaked, Sodding Staked, and Sodding Reinforced by the actual number of square yards of area sodded, completed and accepted.

660.11 Basis of Payment. If required, the City will pay for topsoil liming and fertilizing under Item 659.

The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
660	Square Yard	Sodding Unstaked
660	Square Yard	Sodding Staked
660	Square Yard	Sodding Reinforced

ITEM 661 PLANTING TREES, SHRUBS, AND VINES

661.01 Description
661.02 Plant Materials
661.03 Labeling
661.04 Inspection
661.05 Location and Source of Supply
661.06 Scheduling
661.07 Transportation, Storage, and Handling
661.08 Layout of Plant Materials
661.09 Planting Holes
661.10 Planting Beds
661.11 Backfill Mix
661.12 Planting
661.13 Mulch
661.14 Watering
661.15 Pruning
661.16 Wrapping
661.17 Bracing
661.18 Period of Establishment

661.19 **Warranty**
661.20 **Removal of Stakes and Wrapping**
661.21 **Method of Measurement**
661.22 **Basis of Payment**

661.01 Description. This work consists of furnishing and planting trees, shrubs, vines, and other materials. All work and materials must comply with the current editions of the *American Standard for Nursery Stock ANSI Z60.1*, as published by the American Nursery and Landscape Association, and the American National Standard for Tree Care Operations, ANSI A300, published by the Tree Care Industry Association.

661.02 Plant Materials. Plant materials include all trees, shrubs, vines, and plants required for the project.

A. Provide healthy representatives of all plants, typical of their species or variety, and that exhibit a healthy habit with a strong root system and straight central leader of growth. Provide hardy plants for local climatic conditions grown in nurseries located in the same hardiness zone or colder as the project location for at least two years. Provide plants true to species and variety specified plants, nursery-grown in accordance with good horticultural practices. Provide plants freshly dug during the current season, unless approved by Engineer.

1. Unless specifically noted, provide plants of specimen quality, exceptionally heavy, symmetrical, unquestionably and outstandingly superior in form, structure, and symmetry. Provide sound, healthy, vigorous, well branched, well -structured and densely foliated when in leaf plants; free of disease and insects, eggs, or larvae; and with healthy, well-developed root systems. Provide plants free from physical damage or other conditions that would prevent vigorous growth.

2. The City will reject trees with multiple leaders, unless specified. Do not provide trees with crowns headed back or cut back. The City will also reject trees with a damaged or crooked leader, bark abrasions, sunscald, disfiguring knots, insect damage, or cuts of limbs over 3/4 inch in diameter not completely closed.

3. Provide plants that conform to the measurements specified. The Contractor may use plants larger than those specified if approved by the landscape architect, at no additional cost to the City. Increase the root ball in proportion to the size of the plant, when using larger plants.

4. The City will not allow substitutions of plant materials unless authorized in writing by the engineer. If the Contractor submits written proof that it cannot obtain a specified plant specified, the City will consider using the nearest available size or similar variety, with a corresponding adjustment of the contract price.

B. Anti-Desiccants. Apply anti-desiccants, if specified, to plants in full leaf immediately before digging or as required by the landscape architect. Spray anti-desiccants in a manner that covers all leaves and branches with a continuous protective film.

C. Balled and Burlapped (B&B) Plant Materials. Dig trees designated B&B with firm, natural balls of soil retaining as many fibrous roots as possible, in sizes and shapes as specified in the *American Standard for Nursery Stock*. Wrap balls firmly with non-synthetic, biodegradable burlap and secured with nails and heavy, non-synthetic, biodegradable twine, or equal. Ensure that the root flare shows at surface of ball. The City will not accept trees with loose, broken, processed, or manufactured root balls, except with special written approval before planting.

D. Container Plants. Provide plants grown in containers of appropriate size for the container, as specified in the most recent edition of the American Standard for Nursery Stock, free of circling roots on the exterior and interior of the root ball. Provide container plants grown in the container long enough to establish roots throughout the growing medium.

E. Bareroot and Collected Plants. Provide plants designated as bareroot or collected plants that conform to the *American Standard for Nursery Stock*. Do not dig or install bareroot material after bud break or before dormancy. Immediately after harvesting plants, protect from drying and damage until shipped and delivered to the planting site. Check rootballs regularly and water sufficiently to maintain root viability.

F. Mechanized Tree Spade Requirements. The Contractor may move and plant trees with an approved mechanical tree spade. Limit moving trees with the tree spade to the smaller of either the maximum size allowed for a similar B&B root-ball diameter, according to the *American Standard for Nursery Stock*, or the manufacturer's maximum size recommendation for the tree spade used. Use only a machine approved by the landscape architect prior to use. Plant trees at the designated locations in the manner shown in the plans and in accordance with applicable sections of the specifications.

661.03 Labeling. Name and describe all plant as defined in *Hortus Third*. Attach legible labels to all specimens, or boxes, bundles, and other containers, indicating detailed information covering the botanical genus and the species name, the common name, the size or age of each species or variety, and the quantity contained in the individual bundles, boxes, and bales. Remove all labels before the completion of the establishment period.

661.04 Inspection. The Engineer may inspect plants for conformity to specification requirements and approval where grown and upon delivery. Approval of plants during these inspections will not impair the right of inspection and rejection during progress of the work.

The Engineer will inspect and seal all plant materials on the project site with City seals before use or planting. The Engineer will inspect all plants to ensure they are healthy, vigorous, and free from harmful defects, decay, disfigured stems and roots, plant diseases, and insect pests.

Provide certificates of inspection with the invoice for each shipment of plants as required by law for transportation. File certificates with the engineer prior to acceptance of the material. Inspection by federal or state authorities at the place of plant growth will not preclude rejection of the plants at the site.

The City will give final acceptance of all plant materials only after the materials are planted and have met all the requirements of this item. Remove the City seals from the plant materials after the final inspection.

661.05 Location and Source of Supply. Supply the Engineer with complete and detailed information concerning the source of supply for each item of required plant material within 15 days after receiving the notice of award of the Contract.

661.06 Scheduling. Plant deciduous materials in a dormant condition. If planted in-leaf, spray with an anti-desiccant prior to planting.

Place spring plantings from March 1 to May 31. Place fall plantings from September 1 through November 30. Obtain Engineer approval for planting times other than those indicated.

661.07 Transportation, Storage, and Handling. Take all precautions customary in good trade practice in preparing plants for moving. The City will not approve workmanship that fails to meet the highest standards.

A. Dig, pack, and transport plants with care to ensure protection against injury. Protect all plants from drying out. Transport all plants from nursery sources to the project site with the entire load completely covered for protection from drying winds.

B. Properly protect plants not planted immediately upon delivery with soil, wet peat moss or in a manner acceptable to the Engineer. Water heeled-in plantings daily.

C. Do not bind plants with rope or wire in a manner that could damage or break the branches.

D. Protect plants not planted immediately as follows:

1. Place or store plants within 3 days of site delivery.
2. To prevent drying out or freezing, store plants in a compact group completely covered with a suitable mulch placed around and between the balls.
3. Thoroughly water all plants that cannot be immediately planted so as to keep the roots continually moist. The Engineer may reject plants that are not adequately protected during transportation and storage. Handle all plant materials by the root ball or container.

661.08 Layout of Plant Materials. Before digging, use suitable staking to lay out the locations of all planting holes and beds. Obtain the Engineer's approval of these locations before digging.

661.09 Planting Holes. Dig planting holes that have sloped side walls 'bowl shaped'. Slopes of the side walls shall have a minimum of 1:1 side slopes. The top of the planting holes shall be two times the diameter of the root ball. Planting holes shall be dug to the same depth as the root ball structure. The earth under root balls shall be compacted or unexcavated soil to prevent settlement.

See 661.12 for depth of planting.

Dig planting holes for vines and perennials to a minimum depth and diameter of 6 inches. Make planting holes for rooted cuttings and tree seedlings large enough to accommodate the root system.

661.10 Planting Beds. One month before cultivation, treat all planting beds that are to be developed in areas of existing turf with pre-emergent and post-emergent type herbicides. Use a State-licensed pesticide applicator to apply the herbicide according to the manufacturer's instructions.

Before planting, top dress all planting beds with a minimum of 2 inches of backfill mix, then cultivate it to a depth of 6 inches using a plow, disc, or roto-tiller. Remove all rock or other obstructions encountered while excavating.

661.11 Backfill Mix. Use existing soil unless otherwise specified in planting detail. When using imported topsoil, provide fertile, friable, natural topsoil of loamy character, without mixture of subsoil material, obtained from a well-drained arable site, reasonably free of clay, lumps, coarse sands, stones, plants, roots, sticks and other foreign materials, with an acidity range of between pH 6.0 and 6.8.

A. Identify source of proposed topsoil.

B. The City will allow reuse of topsoil stripped from the site.

661.12 Planting.

A. Planting Balled and Burlapped Trees:

1. If not readily apparent, locate trunk flare by removing twine, burlap, and excess soil.
2. Dig tree hole at least two times wider than the root ball, with sides sloped to an unexcavated or firm base. Provide a hole deep enough such that the located trunk flare, at the first order lateral root, matches finished grade.
3. Lifting only from the bottom of the root ball, position tree in a straight position on a firm pad with the top of trunk flare level with the surrounding soil.
4. Remove all twine from the root ball. If present, remove and discard at least the top one half of the wire basket. Remove burlap from the top to a point halfway down the root ball and discarded. Remove all burlap and wire basket from the root ball if possible.
5. With clean, sharp pruning tools, prune off any secondary/adventitious, girdling, and potential girdling roots.
6. Backfill planting hole with existing unamended soil, and thoroughly water.

B. Planting Containerized or Grow Bag Trees:

1. If not readily apparent, locate trunk flare by removing excess soil.

2. Dig tree hole at least two times wider than the root ball with sloping sides. Provide a hole deep enough such that the located trunk flare, at the first order lateral root, matches finished grade.

3. Create a firm soil mound at the bottom of the planting hole.

4. Remove tree from container or grow bag and select from option a or b:

   a. Completely tease apart root system, repositioning any girdling or potentially girdling roots. Spread roots over soil mound so that trunk flare matches finished grade and results in a straight tree.

   b. With a sharp saw, shave off the entire outer 1 inch (1") of the root ball. Place in planting hole so that trunk flare matches finished grade and results in straight tree.

5. With clean, sharp pruning tools, prune off any secondary/adventitious, girdling, and potential girdling roots.

6. Backfill planting hole with existing unamended soil and thoroughly water.

C. Planting Bare Root Trees:

1. Dig tree hole at least two times wider than the root ball with sloping sides. Dig hole to a depth so the located trunk flare, at the first order lateral root, matches finished grade.

2. Create a firm soil mound at the bottom of the planting hole.

3. Spread roots over soil mound so that trunk flare matches finished grade and results in a straight tree.

4. With clean, sharp pruning tools, prune off any secondary/adventitious, girdling, and potential girdling roots.

5. Backfill planting hole with existing unamended soil and thoroughly water.

D. Planting Seedlings, Groundcovers, Vines or Perennials: For planting seedlings, groundcovers, vines, or perennials in a planting bed see 661.10. Prior to planting seedlings, groundcovers, vines, or perennials in existing turf, remove all grass and weeds by scalping an area that has a minimum diameter of 12 inches. Plant seedlings or perennials in the center of the scalped area using a spade or planting bar.

661.13 Mulch. Mulch the entire planting surface with composted bark applied no less than two inches (2") deep and no more than three inches (3") deep, leaving three inches (3") adjacent to the tree trunk free of mulch. Create a slight berm outside of the ball to help retain water.

661.14 Watering. Use standard watering horticultural procedures to ensure vitality of the Planting Trees, Shrubs, Perennials and Vines. Adequately provide a quantity of rain gauges to accurately track the volume of rain water received by individual or groups of Planting Trees, Shrubs, Perennials and Vines. Monitor the rain gauges and appropriately supplement the volume of rain with landscape watering.

661.15 Pruning. Prune dead, damaged or broken branches only. Do not prune the central leader on trees. See Item 666 for pruning specifications.

661.16 Wrapping. Do not wrap trees unless specified in the planting detail.

661.17 Bracing. Brace all trees by staking as shown on the Standard Drawing LA-1.2. Only flexible or biodegradable ties shall be used when staking trees. Staking should only be used in areas where mower damage, vandalism, or windy conditions are a concern or as directed by the Engineer. The ties shall be loose fitting, (as not to girdle the truck) attached to the lower half of the tree, and allow trunk movement and growth. All staking and wrapping materials shall be removed at the end of the establishment period.

661.18 Period of Establishment. Before final inspection, place all plants and care for them for a period of establishment. The period of establishment begins immediately upon completion of the planting operations and continues until October 1 or date of project final acceptance whichever is earlier.

During the period of establishment, follow standard horticultural practices to ensure the vigor and growth of the transplanted material. Water, remulch, restake, and cultivate as necessary. Perform at least two weeding and mowing programs (around trees, shrubs, and bed edges) of such intensity as to completely rid the planted and mulched areas of weeds and grasses.

661.19 Warranty.

A. The guarantee period for trees, shrubs and vines begins at the date of Final Acceptance.

B. Guarantee healthy and flourishing plant material for a period of one year from the date of Final Acceptance.

C. Replace all plants determined by the Engineer to be dead or in an unacceptable condition that would result in abnormal growth. Replacement shall occur during and at the end of the warranty period as soon as weather conditions permit, and within a specified planting period, at no cost to the City. The City will consider acceptable plants free of dead or dying branches and branch tips and bearing foliage of normal density, size, and color. Replace dead or unacceptable plants with plants that closely match adjacent specimens of the same species. Provide replacements that satisfy all requirements stated in this specification.

D. Guarantee of all replacement plants shall extend for an additional period of one year from the date of acceptance after replacement. The City may elect subsequent replacement or credit for a replacement plant deemed unacceptable during or at the end of the guarantee period.

E. At the end of the guarantee, reset grades that settled below the proposed grades on the drawings.

F. Make periodic inspections during the guarantee period to monitor the condition of the trees. Water the trees as needed to maintain the trees alive and in an acceptable condition.

G. Perform a survival inspection, jointly with the City, in the first growing season before the end of summer. Meet with the City in the fall to compare lists, reconcile differences and develop a spring replacement list.

H. Perform a survival inspection, jointly with the City, at the beginning of the second growing season in April. Meet with the City in April to amend the original replacement list.

I. Plant all replacements by the end of May of the second growing season of the original planting. If the Contractor fails to replace the trees by the designated date, provide the City with a credit for the cost of the tree.

661.20 Removal of Stakes and Wrapping. Remove all stakes and wrapping material from all plants just before the final inspection, with the exception of the replacement plantings that have not been in place for a full growing season. Take ownership of removed items. Use removed materials in the Work when the material conforms to the specifications; if not, then recycle or dispose of the material according to 105.16 and 105.19.

661.21 Method of Measurement. The City will measure the number of plant materials of each species and size, completed and accepted, in place.

661.22 Basis of Payment. The City will pay 40 percent of the bid price for plant materials delivered and accepted at the project site. The City will pay 40 percent of the bid price when the plant materials have been installed. The City will pay the remaining 20 percent of the bid price at the end of the establishment period. Replace all plants not surviving the establishment period at no additional cost to the City.

Costs associated with watering is included in the unit price bid for Item 661 Planting Trees, Shrubs, Perennials and Vines. No additional compensation will be made for Landscape watering.

The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
661	Each	Tree Seedling, (Size), (Species)
661	Each	Perennials, (Size), (Species)
661	Each	Groundcover and Vines, (Size), (Species)
661	Each	Deciduous Shrub, (Size), (Species)
661	Each	Evergreen Shrub, (Size), (Species)
661	Each	Deciduous Tree, (Size), (Species)
661	Each	Evergreen Tree, (Size), (Species)

ITEM 666 PRUNING EXISTING TREES

666.01 Description
666.02 Pruning Objective
666.03 Pruning Methods
666.04 Prune to Clean
666.05 Prune to Thin
666.06 Prune to Raise
666.07 Pruning Cuts
666.08 Brush Disposal
666.09 Method of Measurement
666.10 Basis of Payment

666.01 Description. This work consists of pruning existing trees in accordance to ANSI A300 (Part 1) Pruning Standard and ANSI Z133.1 Safety Standard. Operation shall be supervised by an ISA Certified Arborist.

666.02 Pruning Objective. Purpose of pruning shall meet one or more of the following objectives: reduce risk of failure; provide clearance; reduce shade and wind resistance; and maintain health. Remove no more than 25% of the live crown. Prior to work commencing, seek approval from City Forester with the Department of Recreation and Parks.

666.03 Pruning Methods. Use one or more of the following pruning types to meet the pruning objective.

666.04 Prune to Clean. Selectively remove dead, diseased, detached, cracked, and broken branches one inch or more in diameter.

666.05 Prune to Thin. Selectively remove small live branches to reduce crown density. Thin at the outside edge of the crown.

666.06 Prune to Raise. Selectively remove branches to provide clearance for pedestrians and vehicles. Ensure fourteen feet of road clearance and eight feet of sidewalk clearance.

666.07 Pruning Cuts. Make pruning cuts as close to the trunk or branch as possible without cutting into the branch bark ridge or branch collar and without leaving a stub. Leave a smooth surface with no jagged edges or torn bark.

666.08 Brush Disposal. Dispose of all wood waste by chipping it through a brush chipper and hauling to a licensed wood waste recycling facility.

666.09 Method of Measurement. The City will measure Pruning Existing Trees by the number of each size, completed and accepted.

666.10 Basis of Payment. The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
666	Each	Pruning Existing Trees, 3 to 8-inch Diameter
666	Each	Pruning Existing Trees, 8 to 16-inch Diameter
666	Each	Pruning Existing Trees, 16 to 24-inch Diameter
666	Each	Pruning Existing Trees, 24 to 36-inch Diameter
666	Each	Pruning Existing Trees, 36 inches and Over

ITEM 670 EROSION PROTECTION

670.01 Description
670.02 Materials
670.03 Construction
670.04 Maintenance
670.05 Method of Measurement
670.06 Basis of Payment

670.01 Description. This work consists of furnishing, placing, and maintaining slope, ditch, and vegetated swale erosion protection as shown on the plans.

670.02 Materials. Furnish materials conforming to:

Sodding 660.02
Erosion Control Mats 712.11

For slope erosion protection, the Contractor may use any of the above materials. For ditch erosion protection, use only Item 660 Sodding or Item 671 Erosion Control Mat Type B, C, E, or G or as specified in the plans. For vegetated swale erosion protection, use only Item 671 Erosion Control Mat Type B or as specified in the plans.

670.03 Construction. Install sodding according to Item 660. Install erosion control mats according to Item 671.

670.04 Maintenance. Maintain sodded areas as specified in Item 660. Maintain erosion control mats as specified in Item 671.

670.05 Method of Measurement. The City will measure Slope Erosion Protection, Ditch Erosion Protection, and Vegetated Swale Erosion Protection by the number of square yards completed and accepted. The City will determine the area based on the surface area covered by the slope, ditch, or swale erosion protection.

670.06 Basis of Payment. The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
670	Square Yard	Slope Erosion Protection
670	Square Yard	Ditch Erosion Protection
670	Square Yard	Slope Erosion Protection Mat Type __
670	Square Yard	Ditch Erosion Protection Mat Type __

ITEM 671 EROSION CONTROL MATS

671.01 Description
671.02 Materials
671.03 Construction
671.04 Maintenance
671.05 Method of Measurement
671.06 Basis of Payment

671.01 Description. This work consists of furnishing, placing, and maintaining Types A through I erosion control mats. This work also consists of furnishing, placing, and maintaining seeding and mulching when the seeding and mulching is to be held in place with erosion control mats.

671.02 Materials. Furnish materials conforming to:

Seed and Mulch..... 659
Lime and Fertilizer..... 659
Erosion Control Mats 712.11

If the mat type is not specifically itemized, furnish any mat type listed in 712.11.

Furnish staples consisting of 12-inch No. 11 gage steel wire bent into narrow U-shape with the ends of the staples approximately 1 inch apart producing a 6 inch staple or furnish pins conforming 18 inch long, 1/4 inch in diameter, with attached 1 1/2 inch washer. Drive staples until the staple is flush with the ground surface. Drive pins until the attached washer is flush with the ground surface.

For clay, shale, and other heavy soils, furnish 3-inch steel staples, No. 9 gage or thicker with points approximately 1 inch apart, as required by the Engineer.

671.03 Construction. Before placing any type of temporary erosion control mats, prepare the surface, apply the fertilizer and lime if specified, and seed as specified in Item 659 or as shown on the plans. Place the temporary erosion control mat in the locations shown on the plans.

A. Types A, B, C, E, F, and I. Construct erosion control mat Types A, B, C, E, F, and I as follows:

1. Within 48 hours after seeding and before placing the mat, evenly place mulch over the specified area at the following rates:
   a. For straw mulch, use 30 percent of the rate specified in 659.14.
   b. For wood fiber mulch, use 30 percent of the rate specified in 659.15.
   c. For compost, use the same rate as specified in 659.16.
   d. Asphalt emulsion tack or tackifier is not required.
2. Immediately after mulching, lay the mat strips flat, loose, parallel to the flow of water, and with the mat contacting the ground at all points. For mats placed in ditches, start the construction at the downstream end.
3. Where more than one strip is required to cover the area, overlap the strips at least 4 inches. Overlap the ends at least 6 inches with the upgrade strip on top.
4. Place upgrade slots at the upgrade end of each strip of mat by placing a tight fold of the mat at least 6 inches vertically into the soil. Firmly tamp the soil against the end and staple the mat. If directed by the Engineer, bury other edges exposed to more than normal flow in a similar manner.
5. Place end slots between the ends of strips by placing a tight fold of the mat at least 6 inches vertically into the soil. Firmly tamp the soil and staple the mat.
6. Place check slots by placing a tight fold of the mat at least 6 inches vertically into the soil. Firmly tamp the soil and staple the mat. Space check slots so that one check slot or an end slot occurs within each 50 feet of slope for slopes 3 to 1 or steeper.
7. Bury the edges of the mat where the mat abuts catch basins and other structures.
8. Secure the mat in place with staples driven vertically into the soil. Do not stretch or draw the mat taut during the stapling operation. Install three rows of staples for each strip of mat, with one row along each edge and one row alternately spaced in the middle. Space staples not more than 3 feet apart in each row. Staple all upgrade slots, end slots and check slots across the width, with staples spaced not more than 6 inches apart.
9. After completing the mat installation, seed over top of the mat in areas that the Engineer identifies as disturbed. Use a seed mixture conforming to Item 659 at the rate of 1 pound per 1000 square feet or with a mixture or rate shown on the plans.

B. Type G. Construct erosion control mat Type G according to 671.03.A, with the following exceptions.

1. Do not use mulch under the mat.
2. Overlap edges and ends by 1 1/2 inches.
3. Do not bury the upgrade end or top edge of each strip unless required by the Engineer due to special conditions in the field.
4. The Contractor may elect not to provide check slots. However upgrade slots and end slots will be furnished.
5. Place the mat in contact with the soil.

671.04 Maintenance. Maintain the specified areas until all work in the Contract has been completed and the Engineer issues the final acceptance. Restore damaged areas to the condition and grade existing just before placing the mat. Relime, refertilize, and reseed restored areas according to Item 659. Replace all damaged mats.

671.05 Method of Measurement. The City will measure Erosion Control Mat, Type ___ by the number of square yards completed and accepted. The City will determine the area based on the surface area covered by the erosion control mat.

671.06 Basis of Payment. The City will not pay for maintenance as detailed in 671.04 that is required due to the Contractor's negligence, carelessness, or failure to install erosion controls.

If erosion control items in the Contract are properly placed according to the Contract Documents, the City will pay for maintenance detailed in 671.04 or according to 109.05.

The City will pay for liming and fertilizing of areas covered by the mats under Item 659. The City will not pay for the seeding and mulching performed under or over the mats.

The City will pay for accepted quantities at the contract prices as follows:

Item	Unit	Description
671	Square Yard	Erosion Control Mat, Type ___
671	Square Yard	Erosion Control Mat

700 MATERIAL DETAILS

ITEM 701 CEMENTITIOUS MATERIALS AND CARBONATE MICRO-FINES

701.00 Acceptance.
701.01 Air-Entraining Portland Cement.
701.02 Portland Cement.
701.04 Portland Cement.
701.05 High Early Strength Portland Cement.
701.07 Masonry Cement.
701.09 Slag Modified Portland Cement.
701.10 Micro-Silica.
701.11 Ground Granulated Blast Furnace Slag (GGBFS).
701.13 Fly Ash for Use in Portland Cement Concrete.
701.14 Carbonate Micro-Fines for use in Portland Cement Concrete.

701.00 Acceptance. Provide cements meeting 701.01, 701.02, 701.04, 701.05, 701.07 and 701.09 and certified according to ODOT Supplement 1028; fly ash meeting 701.13 and certified according to ODOT Supplement 1026; ground, granulated blast furnace slag meeting 701.11 and certified according to ODOT Supplement 1034; and micro silica meeting 701.10 and certified according to ODOT Supplement 1045; carbonate micro-fines meeting 701.14 and certified according to ODOT Supplement 1016, without prior sampling, testing and approval by the City. The ODOT Laboratory maintains lists for certified cement, fly ash, GGBFS and micro silica sources.

701.01 Air-Entraining Portland Cement. Provide air-entraining portland cement according to ASTM C 150, Type IA.

701.02 Portland Cement. Provide portland cement according to ASTM C 150, Type II.

701.04 Portland Cement. Provide portland cement according to ASTM C 150, Type I.

701.05 High Early Strength Portland Cement. Provide high early strength portland cement according to ASTM C 150, Type III.

701.07 Masonry Cement. Provide masonry cement according to ASTM C 91.

701.09 Slag Modified Portland Cement. Provide slag modified portland cement according to ASTM C 595, Type IS (< 25).

701.10 Micro-Silica. Provide micro-silica according to ASTM C 1240. Do not use micro-silica admixtures in dissolvable bags.

701.11 Ground Granulated Blast Furnace Slag (GGBFS). Provide ground granulated blast furnace (GGBFS) according to ASTM C 989, Grade 100 minimum.

701.13 Fly Ash for Use in Portland Cement Concrete. Provide fly ash according to ASTM C 618, Class C or F, except ensure a maximum loss on ignition (LOI) of 3 percent.

The City may approve fly ash treated with a chemical conforming to ODOT Supplement 1115 from sources certified according to ODOT Supplement 1026 and with an LOI greater than 3 percent.

701.14 Carbonate Micro-Fines for use in Portland Cement Concrete. Provide carbonate micro-fines (CMF) according to ASTM C1797, except modify Type C according to the properties shown in Table 701.14-1 below:

TABLE 701.14-1 CHEMICAL AND PHYSICAL REQUIREMENTS

Parameter	Type C
$MgCO_3$, %	≥43
Sum of $CaCO_3$ + Mg CO_3, % by mass	≥ 98
Methylene blue value (mg/g)	≤ 3
Particle size distribution,	minimum % passing
No. 20 sieve	100
No. 50 sieve	80-100
No. 100 sieve	
No. 200 sieve	10-90
No. 325 sieve	5-70

ITEM 702 ASPHALT MATERIAL

702.00 Application Temperatures.
702.01 Asphalt Binders.
702.02 Cut-Back Asphalt.
702.03 Cut-Back Asphalt Emulsions.
702.04 Emulsified Asphalts.
702.05 Asphalt Primer for Waterproofing.
702.06 Asphalt for Waterproofing.

702.07 Asphalt Emulsion MWS.
702.08 Cold Liquid-Applied Elastomeric Waterproofing Membrane.
702.12 Non-Tracking Asphalt Emulsion.
702.13 SBR Asphalt Emulsion.
702.14 SBR Emulsion.
702.16 Polymer Emulsified Binder.
702.17 Crack Sealant.

Acceptance. The City may accept asphalt binders 702.01 and liquid asphalts 702.02, 702.03, and 702.04 for shipment to and immediate use in construction projects. The City will accept these materials according to City Supplement 1032. Material will meet specification requirements and no tolerances are given for material falling out of specification requirements.

702.00 Application Temperatures. Apply asphalt materials, according to the temperature ranges specified in Table 702.00-1.

TABLE 702.00-1

Type and Grade of Material	Application Temperature Range °F	
	Spray	Mix
MC-30	50 to 120	---
MC-70	75 to 150	---
MC-250	100 to 225	100 to 225
MC-800	150 to 250	150 to 225
MC-3000	225 to 275	200 to 250
All Emulsions	50 to 160	50 to 140
Asphalt Primer for Waterproofing	50 to 80	---
Asphalt for Waterproofing	300 to 350	---
CBAE 350, CBAE 350 SP	100 to 150	100 to 150
CBAE 800, CBAE 800 SP	125 to 175	125 to 175
Primer 20	60 to 120	---
Primer 100	75 to 125	---
Asphalt Binders	350 Max.	325 Max.
Asphalt Binders Polymer modified with SB, SBR, SBS, or Elvaloy	375 Max	350 Max.

702.01 Asphalt Binders.

General. According to AASHTO M 320-10 Table 1 except as follows.

PG Binders with the suffix "M" (e.g. Ensure PG 70-22M, PG 76-22M, PG 88-22M, and PG 64-28 meet the requirements of Table 702.01-1.)

Do not use an independent laboratory owned or operated, in whole or part, by the binder supplier, Contractor, or affiliates of either.

Materials and Manufacture. Replace the requirements of AASHTO M 320-10 Table 1 Section 5 "Materials and Manufacture" Section with the following:

5.1 Supply PG Binder from the refining of crude petroleum, or combination of asphalt binders from the refining of crude petroleum, or asphalt binders and suitable liquid from the refining of crude petroleum, and possible organic modifiers for performance enhancement. The City will consider material from the crude refining stream as neat. The Contractor may use liquid from crude refining for adjustments, but do not use liquid from crude refining for the purpose of substitution of crude refined asphalt binder in a PG Binder. In the event of a failure investigation where asphalt binders exhibit unusual properties, the City may request that a supplier provide information about the makeup of a PG Binder. Failure to cooperate will mean removal from City Supplement 1032 certification.

5.2 The City will accept a modifier dissolved or reacted in asphalt binder to improve its performance consisting of any approved material of suitable manufacture that is proven compatible with asphalt binder (does not separate appreciably in routine storage), and that is dissolved or reacted in asphalt binder to improve its performance. Performance enhancement is defined as a decrease in the temperature susceptibility of the asphalt binder while maintaining or improving desirable properties in a neat asphalt binder such as coat ability, adhesiveness and cohesiveness. Unless otherwise noted, limit modifiers to no more than 6.0 percent by PG Binder weight.

5.3 The City must approve the use of previously used materials in a PG Binder. Since no standard test procedures exist for reprocessed materials, because developers of the original tests did not have the use of such materials in mind, the City will choose appropriate test methods for review. City approval will not relieve the binder supplier from full responsibility for content and use of any previously used material in a PG Binder nor guarantee suitable performance enhancement as defined above. The detected presence in a PG Binder sample of any unapproved previously used material will mean immediate removal from City Supplement 1032 certification. Limit approved previously used materials to 5.0 percent by PG Binder weight maximum and provide a written certification to OMM stating the exact percent used, the source, and any brand or trade names. Approved previously used materials are only allowed to be used to produce PG 58-28 and PG 64-28 and suppliers must get recertified per City Supplement 1032 for these PG grades. OMM letter of approval must be submitted to the Laboratory before use.

5.4 Provide a homogeneous PG Binder, free from water and deleterious materials that will not foam when heated to 350 ºF. Prove the asphalt binder, before modification or after modification if liquid modifier used, is fully compatible with a negative result by means of the Spot Test per AASHTO T 102 using standard naphtha solvent. If standard naphtha shows a positive result, the City will allow a retest using reagent grade 35 percent Xylene/ 65 percent Heptane (volume).

5.5 Provide a 99.0 percent soluble PG Binder as determined by AASHTO T44 or ASTM D7553The City will not accept any insoluble component containing fibers or discrete particles greater than 75 µm.

5.6 Ensure a minimum flash point of 500 ºF minimum. Ensure a 0.75 percent maximum mass change on RTFO of the final PG Binder grade.

5.7 Ensure a Penetration (AASHTO T49) of no more than 77.

5.8 The City will not require Direct Tension testing, unless otherwise required in this specification.

Requirements for PG Modified Binder. Furnish PG Modified Binder according to the requirements of Table 702.01-1 by modifying a non-oxidized, non-air blown, neat asphalt binder by using a styrene butadiene latex rubber compound (SBR polymer), a styrene butadiene styrene polymer block copolymer (SB, SBS polymer), an ethylene/ nbutyl acrylate/ glycidyl methacrylate copolymer (Elvaloy) as specified or Ground Tire Rubber (GTR) according to ODOT's Supplemental Specification 887. For SB, SBS products, provide a certification from the polymer supplier that the polymer used meets a minimum 68 percent by weight butadiene content. Perform SB, SBS, Elvaloy or GTR modification prior to shipment to the asphalt concrete mixing plant (pre-blend). Perform SBR modification at the asphalt concrete mixing plant (post-blend) or prior to shipment to the asphalt concrete mixing plant (pre-blend) where allowed by specification.

Polyphosphoric acid (PPA) is allowed in PG binders as follows. PPA is a polymer of orthophosphoric acid. When using PPA ensure all the applicable requirements of the required PG binder in Table 702.01-1 are met. Ensure PPA does not contain water. To retain City Supplement 1032 certification, suppliers of PPA modified asphalt will provide a written certification to the Laboratory that the amount of PPA used is less than 1.0% by weight of neat binder. Suppliers of PPA can have their City Supplement 1032 certification removed for not following the above PPA requirements.

For each project, obtain a handling guide from the PG Modified Binder supplier specifying temperature, circulation, shelf life, and other requirements for assuring the PG Modified Binder will perform as desired. Give this handling guide to the Engineer and place a copy in the plant control room and plant laboratory.

If PG Modified Binder is retained at the asphalt concrete mixing plant for more than two weeks before use or beyond the supplier recommended shelf life, whichever is less, a top and bottom sample test (material property difference between samples taken from the top and bottom of the storage tank) will be performed by the Laboratory on samples retrieved by the Contractor at the Engineer's direction. Do not use material on hand until approved.

TABLE 702.01-1

MATERIAL REQUIREMENTS FOR PG MODIFIED BINDER

Test / Requirement	SBR Polymer		Pre Blended Binder				Note
Final PG Binder Grade	70-22M (a, b)	64-28 (b)	64-28 (a)	70-22M (a,k)	76-22M (a,k)	88-22M (a,l,m)	c
Actual Pass Temperatures	Report						i
RTFO Mass Change, percent max	0.75						d
Phase Angle, max	78		78		74		d
Elastic Recovery, min			65		75	90	e, d
Toughness, in. lb	125	105					f, d
Tenacity, in lb.	70	80					f, d
Elongation, in. min	20	20					f, d
Ductility, in. min	28	28					j, d
Separation, F max	10						g, d
Homogeneity			None Visible				h, d

a. Preblended Binder. Use a base neat asphalt binder that is a -22 grade for 70-22M and 76-22M. Use a base neat asphalt binder that is a -28 grade for 64-28. 64-28 can be neat, PPA modified or modified with SB, SBS or Elvaloy. 64-28 PPA only modified does not have to meet the phase angle or elastic recovery requirements. Ensure SB, SBS or Elvaloy modified 64-28 meets all requirements listed.

b. Post-blended Binder made from neat City Supplement 1032 certified or preapproved standard PG Binder grade and SBR solids amount equal to or above 3.5 percent by weight of total binder to achieve the PG Binder grade. Ensure all listed properties are met.

c. Without Direct Tension, graded with actual pass temperatures.

d. PG Modified Binder.

e. AASHTO T301, 10cm @ 77 ºF, hold 5 min. before cutting, on RTFO material for SB, SBS, and Elvaloy. Note elongation after one hour to the nearest 0.01 cm and report elastic recovery to nearest 0.1%.

f. ASTM D 5801, 50cm/min @ 77 ºF.

g. Condition samples according to ASTM D 7173. Conduct softening point difference of top and bottom of tube per AASHTO T53. Compatibility of polymer and neat binder is sole responsibility of supplier. Formulate PG Modified Binder to retain dispersion for 3 days minimum.

h. Heat a minimum 400 gram sample at 350 ºF for 2.5-3 hours. Pour entire sample over a hot No. 50 sieve at 340 ºF. Look for retained polymer lumps.

i. Actual high and low temperature achieved by PG Modified Binder beyond required grade, but will not grade out to the next standard PG Binder grade for low temperature.

j. AASHTO T51, @ 39 ºF, 1 cm/min.

k. SB, SBS, Elvaloy or ODOT's Supplemental Specification 887 GTR.

l. SB, SBS, Elvaloy.

m. The requirements of 3.0Pa*s maximum for the rotational viscosity for 88-22M may be waived at the discretion of the City if the supplier warrants that the asphalt binder can be adequately pumped, mixed, and compacted at or below the temperature requirements in Table 702.00-1. Do not exceed 10.0 Pa*s rotational viscosity using the #27 spindle at time of shipment.

702.02 Cut-Back Asphalt. Provide medium curing cut-back asphalt according to AASHTO M 82. Instead of viscosity on the residue, the penetration in note 2 (AASHTO M 82) will govern.

702.03 Cut-Back Asphalt Emulsions. Prepare emulsions by compounding a suitable volatile solvent and water with 702.01 asphalt to produce emulsions according to Table 702.03-1.

TABLE 702.03-1

	CBAE-350	CBAE-350 Special	CBAE-800	CBAE-800 Special	Primer 20	Primer 100
Kinematic Viscosity at 60 °C, Centistokes	350-700	350-700	800-1600	800-1600	20-40	100-200
Water Content [1], %	4-12	4-12	4-12	4-12	3-8	3-8
Volatile Solvent [1], %	12-25	12-25	10-20	10-20		
Asphalt Content [1], %	67+	67+	72+	72-	45+	60-
Adhesion Test [1]	[2]	[2]	[2]	[2]		
Wet Stone Coating Test [1]		[2]		[2]	[2]	[2]
Stripping Test[1]		[2]		[2]		
	Tests on Residue From Distillation					
Penetration at 25 °C	80-150	80-150	80-150	80-150	100-200	100-200
Ductility at 25 °C, in. cm	100+	100+	100+	100+	100+	100+
Total Binder (Sol. in CSx), %	99+	99+	99+	99+	99+	99+

[1] Perform tests according to ODOT Supplement 1014.

[2] Meets

702.04 Emulsified Asphalts. Provide emulsified asphalts according to AASHTO M 140 or AASHTO M 208 except specification limits will be producible for at least 30 days from sample date. Use Saybolt Furol for viscosity.

702.05 Asphalt Primer for Waterproofing. Provide asphalt primer for waterproofing according to ASTM D 41 Type 2.

Furnish materials according to the City's QPL.

702.06 Asphalt for Waterproofing. Provide asphalt for waterproofing according to ASTM D 312, Type III.

Furnish materials according to the City's QPL.

702.07 Asphalt Emulsion MWS. Prepare asphalt emulsion MWS from a base material according to 702.01, except vary the penetration to meet the float test and penetration specified below. Ensure that the emulsion coats the aggregate readily, thoroughly, and uniformly. Ensure that the specified characteristics do not change during transportation, normal storage and that the emulsion satisfies the following criteria when tested according to AASHTO T 59 within 30 days after sample date:

Saybolt furol viscosity at 77 °F, seconds	50+ [1]
Asphalt residue, percent	68+
Settlement, 7 days, percent	5-
Sieve test	0.1-
Coating test	[2]
Oil distillate, percent	7-
Withstand freezing to	-10 ºF [3]
Particle charge	Negative
Penetration, 77 °F [6]	[4]
Float test at 140 °F, seconds [6]	1200+ [5]
Total bitumen soluble CS% Solubility [6]	97.5+
Ash content, percent [6]	2.0-

[1] Pumpable.

[2] Use aggregates to test the emulsion from sources standardized by the Laboratory. Use aggregates consisting of 100 percent passing a 3/8 inch sieve and 0 percent passing a 1/4 inch sieve. Wash the standard reference aggregates with distilled water until free of dust, and dry them.
Weigh 3.280 ounces of the dry graded reference aggregate into a suitable container. Weigh 0.247 ounces of the emulsion onto the aggregate in the container, and vigorously mix the contents for 5 minutes. After mixing, thoroughly coat the stone. Completely immerse the mixture in tap water, and immediately pour off the tap water. Ensure a 90 percent coating of the aggregate surface area.

[3] When shipped after October 1 and before April 15, except emulsion stored and mixed at temperatures of emulsion, aggregate, and atmosphere above 40 °F.

[4] Select the penetration within the following ranges of the designation specified:

[5] AASHTO T 50, except immediately pour residue from distillation into the float collar at 500 °F; or if the residue has been allowed to cool, heat it again to 500 °F and pour it into the float collar.

[6] Test on residue from distillation per AASHTO T44 or ASTM D7553

Designation	Penetration at 77 °F
MWS 300	300+
MWS 150	150 to 300
MWS 90	90 to 150
MWS 60	60 to 90

702.08 Cold Liquid-Applied Elastomeric Waterproofing Membrane. Provide Cold Liquid-Applied Elastomeric Waterproofing Membrane as follows:

Hardness Type 00, min.	50	ASTM D-2240 as modified in Section 6.5 of ASTM C-836
Low temperature crack bridging	no cracking	ASTM C-1305 as modified in Section 6.7 of ASTM C-836
Adhesion-in-peel after water immersion	1	ASTM C-794 as modified in Section 6.9 of ASTM C-836 min. Lbf (no optional test allowed)
Extensibility after heat aging, min. in	¼	ASTM C-1522
Hydrostatic Resistance min. psi	25	ASTM C-1306

Provide Certified Test Data proving that the material complies with the specification requirements.

702.12 Non-Tracking Asphalt Emulsion. Provide certified non-tracking asphalt emulsion material per City Supplement 1032. Emulsion will comply with all specification requirements for at least 30 days after sample date.

702.13 SBR Asphalt Emulsion. Provide material consisting of asphalt emulsion SS-1, SS-1h, CSS-1 or CSS-1h per 702.04 and City Supplement 1032, blended with SBR emulsion per 702.14, to produce a residual mixture of asphalt binder and SBR solids having a composition of 97.0 ± 0.3 percent asphalt binder and 3.0 ± 0.3 percent SBR solids by weight.

Furnish a certification to the Engineer and signed by the Contractor containing the following:

A. The weight of SBR emulsion blended with the asphalt emulsion.

B. The weight of asphalt emulsion blended with the SBR emulsion.

C. The SBR emulsion manufacturer certification per 702.14.

D. The percent of asphalt binder in the asphalt emulsion (residue by distillation).

E. The percent of SBR solids in the SBR emulsion.

F. The percent of SBR solids in the mixture of asphalt binder residue and SBR solids.

G. Name of Certified asphalt emulsion producer and asphalt emulsion.

Determine the weight of the SBR emulsion needed for addition to a designated weight of asphalt emulsion to provide the percent of SBR solids in the mixture of asphalt residue and SBR solids using the following formula:

$$X = \frac{0.0309(B)(W)}{(A)}$$

where:

X = pounds of SBR emulsion
A = percent SBR solids in the SBR emulsion
B = percent of asphalt residue of the asphalt emulsion
W = pounds of the asphalt emulsion

For field blending, thoroughly mix the asphalt emulsion and SBR emulsion as follows before application: Add to the distributor the asphalt emulsion and the required amount of the SBR emulsion of the appropriate SBR emulsion type (i.e. cationic or anionic). Heat and circulate the distributor contents for at least 30 minutes to ensure complete blending. Re-circulate the distributor contents for 10 minutes just prior to application. If the distributor has set for 12 hours without circulation, repeat the heating and circulating of the distributor contents for 30 minutes prior to application.

Draw samples of the mixed SBR and asphalt emulsion after mixing the materials as indicated above. Emulsion will comply with all specification requirements for at least 30 days after sample date.

702.14 SBR Emulsion. Use a cold polymerized Styrene Butadiene synthetic rubber (SBR) emulsion in latex form specifically compounded for use in asphalt binders and asphalt emulsions. Ensure the manufacturer of the SBR emulsion furnishes a written certification of the total SBR solids content of the SBR emulsion and actual test results showing compliance with both of the following requirements:

A. SBR emulsion:

Type of SBR Emulsion:	Anionic	Cationic
SBR solids Styrene Butadiene Ratio	27 ±5 : 73 ±5	27 ±5 : 73 ±5
Total SBR solids, % by weight	60-72	60-72
SBR solids Residual Styrene, % by weight	0.1 max	0.1 max
Ash, % of total SBR solids by weight	3.5 max	3.5 max
pH	9-11	4-6
Viscosity, Brookfield Units, Model RVF, spindle No 2 @20 RPM@ 77° F	2000 max	2000 max

B. Combination of 3.0 – 4.0 % SBR solids with 96.0 – 97.0 % PG 64-22 meeting 702.01 by weight:

Toughness inch-pounds, Minimum	133
Tenacity, inch-pounds, Minimum	80

702.16 Polymer Emulsified Binder. Material will meet specification requirements of the table below.

TABLE 702.16 POLYMER EMULSIFIED BINDER

Emulsion (AASHTO T 59)	Type A (b)	Type B (c, g)
Saybolt Furol Viscosity (g)	120-550	20-100
Storage stability, 24 hrs., % difference, max (a)	1	1
Demulsibility, 35 ml of 0.8% Dioctyl Sodium Sulf., min	50	60
Demulsibility, 35 ml of 0.02N, $CaCl_2$, %, min		60
Sieve test, (distilled water), %, max	0.1	0.05
Distillation to 177 ºC, residue % solids (d)	66	63
Oil distillate, %, max	2	2
Distillation Residue		
Penetration, 100g, 5 sec @77 ºF AASHTO T 49	70-125	90-150
Softening point, º C, min AASHTO T 53	57	
Solubility, %, min AASHTO T44 or ASTM D7553	97.5	97.5
Elastic Recovery, 50 ºF, %, min AASHTO T 301 (e), (f)	60	58

Notes:
(a) After standing undisturbed for 24 hours, the surface should show a smooth homogeneous color throughout with no white, milky colored substance.
(b) CRS-2P, test within 20 days of project sampling. Limits for both certified source and project samples.
(c) CRS-1P and HFRS-1P, test within 20 days of project sampling. Limits for both certified source and project samples.
(d) See ODOT Supplement 1013.
(e) Straight molds. Hold at test temperature for 90 minutes. Place in ductilometer and elongate 20 cm at 5 cm/min. Hold for 5 minutes and cut. After 1 hour retract the broken ends to touch and note elongation in cm (X) to the nearest 0.01cm. Percent Recovery = ((20-X)/20) x 100. Report elastic recovery to nearest 0.1%.
(f) SBR, SBS, & SB
(g) Minimum of 70 SFS for project acceptance

702.17 Crack Sealant.

A. Type I Crack Sealant. Conform to 705.04.

B. Type II Crack Sealant. Provide a mixture of PG 64-22 certified binder (City Supplement 1032) and polyester fibers (recycled fibers not permitted) according to the following requirements:

Denier; ASTM D 1577* ..... 3.0 to 6.0
Length ..... 0.25 ± 0.02 inch
Crimps; ASTM D 3937 .....None
Tensile str, min. ASTM D2256* .....70,000 psi
Specific gravity ..... 1.32 to 1.40
Minimum melting temperature.....475 ºF
Ignition temperature .....1000 ºF min.

* Obtain this data prior to cutting the fibers.

Use fiber and fiber manufacturer from the City's Qualified Products List.

Combine materials so that fibers make up a minimum of 5.0 percent by total weight of the asphalt binder. Provide combined materials according to the following properties:

Strength (at break) at 72 ºF	350 psi min.
at 0 ºF	500 psi min.
Elongation (at break) at 72 ºF	50 percent min.
at 0 ºF	20 percent min.

The City will permit the option for using premixed and prepackaged Type II crack sealant provided (1) the Contractor provides fibers and the fiber binder according to the requirements as shown and, (2) the Contractor provides fiber binder according to the manufacturer's specifications. Furnish certified test data from the fiber binder manufacturer annually to the Laboratory, and when requested by the Laboratory. Furnish a letter of certification with each shipment stating that the material complies with specification requirements.

C. Type III Crack Sealant. Provide a mixture of PG 64-22 certified binder (City Supplement 1032) and polypropylene fibers (recycled fibers not permitted) according to the following requirements:

Denier; ASTM D 1577* ..... 15 ±3
Length, ... 0.39 ± 0.08 inch
Crimps; ASTM D 3937 .....None
Tensile strength, min, ASTM D 2256* .....40,000 psi
Specific gravity ..... 0.91 ± 0.04
Minimum melting point .....320 ºF

* Obtain this data prior to cutting the fibers.

Use fiber and fiber manufacturer from the City's Qualified Products List.

Combine materials so that fibers make up a minimum of 7.0 percent by total weight of the asphalt binder. Provide combined materials according to the following properties:

Strength (at break) at 72 ºF	350 psi min.
at 0 ºF	500 psi min.
Elongation (at break) at 72 ºF	50 percent min.
at 0 ºF	20 percent min.

D. Type IV Crack Sealant.

Provide a prepackaged, preapproved mixture of modified binder according to the following properties and minimum 2.0 percent polyester fibers (recycled fibers not permitted) according to the following properties.

Modified binder:

Cone penetration, 77 ºF 50-90
Flow, 140 ºF .....1.0 cm max
Resilience, 77 ºF..... 25-60 percent
Ductility, 77 ºF ..... 40 cm min
Bond, 0 ºF, 100 percent ext. Pass ..... 5 cycles
Impact, 0 ºF ..... Pass
Compression recovery..... 0.40 min
Recommended pour temperature.....380 ºF
Safe heating temperature .....410 ºF

Fiber must meet requirements for Type II polyester fiber. Use fiber and fiber manufacturer from the City's Qualified Products List.

Safe heating temperature .....400 ºF
Softening point .....190 ºF
Viscosity, 400 ºF ..... 3000 cp min
Cone penetration, 77 ºF 25-45
Workability - Capable of melting and application through a pressure feed, indirect heated and agitated melter
Flexibility* ..... Pass

* 1 inch sample at -20 ºF, 90 degree bend, 10 sec

Use crack sealant and crack sealant manufacturer from the City's Qualified Products List.

ITEM 703 AGGREGATE

703.01 General.
703.02 Aggregate for Portland Cement Concrete.
703.03 Fine Aggregate for Mortar or Grout.
703.04 Aggregate for Asphalt Concrete Base (301 and 302).
703.05 Aggregate for Asphalt Concrete (Intermediate and Surface Courses), Prime Coat (408), and Microsurfacing (421).
703.06 Sand Cover (407 and 408).
703.07 Mineral Filler.
703.08 Aggregate for Pipe Bedding and Initial Backfill.

703.10 Screenings.
703.11 Structural Backfill.
703.13 Coarse Aggregate for Items 305, 306, 451 and 452.
703.14 Non Pavement Open-Hearth, Electric Arc Furnace, and Basic Oxygen Furnace Steel Slag Aggregate Use.
703.16 Suitable Materials for Embankment Construction.
703.17 Aggregate Materials for 304.
703.18 Materials for Item 410, 411, and 617.
703.19 Rock and Aggregate Materials for Item 601.

703.01 General.

The following abbreviations apply:

CCS	Crushed Carbonate Stone.
ACBFS	Air Cooled Blast Furnace Slag
GS	Granulated Slag
RAP	Recycled Asphalt Pavement
RPCC	Recycled Portland Cement Concrete
OH	Open Hearth Slag
EAF	Electric Arc Furnace Slag
BOF	Basic Oxygen Furnace Slag
PCS	Petroleum Contaminated Soil

Pre-qualified Aggregate Supplier Program (City Supplement 1069). Provide aggregate materials to the City of Columbus from pre-qualified suppliers.

A. Soundness. When the major portion of the unsound material in a coarse aggregate acquires a mud-like condition when tested for soundness, ensure a maximum loss of 5 percent for all uses.

B. Stockpiles. Use stockpiling and loading methods that permit ready identification of the aggregates and to minimize segregation. Clean the sites for stockpiles before storing materials. Do not remove aggregates from stockpiles within 1 foot of the ground until final cleanup of the work. Do not use material mixed with foreign matter, wood or other size or grades of aggregates.

Handle aggregates in such a manner as to ensure that the moisture content remains reasonably uniform for each day's run.

C. Size. Provide aggregate according to the size specified in the material specification, the construction item, or as shown in AASHTO M 43.

D. Method of Test. Provide aggregate tested by the following methods:

Amount finer than No. 200 sieve CS1004
Clay lumps OS1017
Coal and lignite ..... AASHTO T 113
Crushed pieces .....ASTM D 5821
Deleterious materials..... OS1029
Effect of organic impurities on
strength of mortar.....AASHTO T 71
Liquid limit .....AASHTO T 89
Percent of wear, Los Angeles
abrasion test..... AASHTO T 96 or ASTM C 535
Plasticity index.....AASHTO T 90
Sieve analysis.....CS1004, OS1005
Sieve analysis of mineral filler.....AASHTO T 37
Sodium sulfate soundness test,
5 cycle .....AASHTO T 104
Specific Gravity and percent absorption
for fine and coarse aggregate..... OS1031
Unit weight.....AASHTO T 19
Lightweight chert in aggregates .....AASHTO T 113
Sand equivalent .....AASHTO T 176
Uncompacted void content.....AASHTO T 304
Flat and elongated .....ASTM D 4791
Rapid freezing and thawing.... ASTM C 666, Procedure B
Insoluble residue of carbonate
aggregates.....ASTM D 3042
Compaction testing of Unbound Materials.....SS1501
In place gradation sampling CS1090
Soundness of aggregate by freezing
and thawing .....AASHTO T 103
Micro-Deval .....AASHTO T 327
Silicon Dioxide.....ASTM C 146

Sodium sulfate soundness test,
Rock slabs .....ASTM D 5240

F. Restrictions. When using an aggregate source specially designated with a "SR or SRH" according to ODOT's *Guidelines for Maintaining Adequate Pavement Friction in Surface Pavements,* the City will restrict use of the aggregate source in surface pavement according to the methods in the guidelines. View ODOT's document, *Guidelines for Maintaining Adequate Pavement Friction in Surface Pavements*, on ODOT's OMM website under "Material Information by Category, Aggregate", or ODOT's Office of Pavement Engineering's website.

TABLE 703.01 (AASHTO M43) STANDARD SIZES OF PROCESSED

Size No.	Nominal size [1] square openings inch	mm	Amounts finer than each laboratory sieve (square openings), percent by weight 4 in. 100 mm	3 1/2 in. 90 mm	3 in. 75 mm	2 1/2 in. 63 mm	2 in. 50 mm	1 1/2 in. 37.5 mm	1 in. 25 mm	3/4 in. 19 mm	1/2 in. 12.5 mm	3/8 in. 9.5 mm	No. 4 4.75 mm	No. 8 2.36 mm	No. 16 1.18 mm	No. 50 300 µm	No. 100 150 µm
1	3 1/2 to 1 1/2	90 to 37.5	100	90 to 100		25 to 60		0 to 15		0 to 5							
2	2 1/2 to 1 1/2	63 to 37.5			100	90 to 100	35 to 70	0 to 15		0 to 5							
24	3 1/2 to 3/4	63 to 19			100	90 to 100		25 to 60		0 to 10	0 to 5						
3	2 to 1	50 to 25				100	90 to 100	35 to 70	0 to 15		0 to 5						
357	2 to No. 4	50 to 4.75				100	95 to 100		35 to 70		10 to 30		0 to 5				
4	1 1/2 to 3/4	37.5 to 19					100	90 to 100	20 to 55	0 to 15		0 to 5					
467	1 1/2 to No. 4	37.5 to 4.75					100	95 to 100		35 to 70		10 to 30	0 to 5				
5	1 to 1/2	25 to 12.5						100	90 to 100	20 to 55	0 to 10	0 to 5					
56	1 to 3/8	25 to 9.5						100	90 to 100	40 to 85	10 to 40	0 to 15	0 to 5				
57	1 to No. 4	25 to 4.75						100	95 to 100		25 to 60		0 to 10	0 to 5			
6	3/4 to 3/8	19 to 9.5							100	90 to 100	20 to 55	0 to 15	0 to 5				
67	3/4 to No. 4	19 to 4.75							100	90 to 100		20 to 55	0 to 10	0 to 5			
68	3/4 to No. 8	19 to 2.36							100	90 to 100		30 to 65	5 to 25	0 to 10	0 to 5		
7	1/2 to No. 4	12.5 to 4.75								100	90 to 100	40 to 70	0 to 15	0 to 5			
78	1/2 to No. 8	12.5 to 2.36								100	90 to 100	40 to 75	5 to 25	0 to 10	0 to 5		
8	3/8 to No. 8	9.5 to 2.36									100	85 to 100	10 to 30	0 to 10	0 to 5		
89	3/8 to No. 16	9.5 to 1.18									100	90 to 100	20 to 55	5 to 30	0 to 10	0 to 5	
9	No. 4 to 16	4.75 to 1.18										100	85 to 100	10 to 40	0 to 10	0 to 5	
10	No. 4 to 0 [2]	4.75 to 0 [2]										100	85 to 100				10 to 30

[1] Numbered sieves are those of the United States Standard Sieve Series.

[2] Screenings.

Where standard size of coarse aggregate designated by two or three digit numbers are specified, obtain the specified gradation by combining the appropriate single digit standard size aggregates by a suitable proportioning device which has a separate compartment for each coarse aggregate combined. Perform the blending as directed by the Laboratory.

703.02 Aggregate for Portland Cement Concrete.

A. Fine Aggregate.

1. Provide fine aggregate consisting of natural sand or sand manufactured from stone.

2. Sieve analysis.

Sieve Size	Total Percent Passing
3/8 inch	100
No. 4	95 to 100
No. 8	70 to 100
No. 16	38 to 80
No. 30	18 to 60
No. 50	5 to 30
No. 100	0 to 10
No. 200	0 to 5

The City may reject sand if the fineness modulus of a job control sample of sand from any source vary by more than 0.20 percent from that of the representative sample from that source.

3. Physical properties.

	Maximum
Loss, sodium sulfate soundness test	
Item 305	12 %
Items 255, 256, 451, 452, 511, 515, 519, 526, 602, 603, 604, 608, 609, 610, 622, and 625	10 %
Aggregations of soil, silt, etc. by weight	0.5 %

When tested for the effect of organic impurities on strength of mortar, ensure that the compressive strength at 3 and 7 days of mortar made with untreated sand is not less than 95 percent of the compressive strength of mortar made with treated sand.

Provide fine aggregate for Items 255, 256, 451, 452, 526, and 511 deck slabs with at least 25 percent siliceous particles as determined by the acid insoluble residue test [ASTM D3042]. Ensure material has been tested and results are on file at the Laboratory. For sources not tested and on file at the laboratory, submit certified test data from an AMRL accredited independent laboratory verifying the minimum 25 percent.

B. Coarse Aggregate.

1. Provide coarse aggregate consisting of washed gravel, CCS, or crushed ACBFS.

2. Physical properties.

Percent of wear, Los Angeles test, maximum (CCS or washed gravel)	40 %
Unit weight, compacted, minimum (slag)	70 lb/ft^3
Loss, sodium sulfate soundness test, maximum:	
Item 305	15 %
Items 255, 256, 451, 452, 511, 519, 526, 602, 603, 604, 609, 610, 622, and 625	12 %
Item 515	10 %

Do not exceed the following percentages of deleterious substances:

	Percent by Weight	
Material Type	**Super-Structure**	**All Other Concrete**
Soft pieces	2.0	3.0
Coal and lignite	0.25	1.0
Clay lumps	0.25	0.25
Pieces having a length greater than 5 times the average thickness	15	15
Shale and shaly material	0.5	1.0
Limonitic concretions	0.5	1.0
Alkali	0.5	1.0
Metallic particles	0.5	1.0
Chert, that disintegrates in 5 cycles of the soundness test	0.5	1.0

Additional requirement for ACBFS aggregate:

Total Sulfur as S, maximum (ASTM C114)	2.0%

3. Amount passing the No. 200 sieve. Ensure that the percent by weight of material passing the No. 200 sieve in the aggregate portion of the concrete mix does not exceed the following:

	Percent by Weight	
Material Type	**Super-Structure**	**All Other Concrete**
CCS and crushed ACBFS	3.4	3.8
Washed gravel	2.0	2.2

703.03 Fine Aggregate for Mortar or Grout.

A. Provide fine aggregate consisting of natural sand or sand manufactured from stone or ACBFS.

B. Sieve Analysis.

	Natural Sand	Manufactured Sand
Sieve Size	**Total Percent Passing**	
No. 4	100	100
No. 8	95 to 100	95 to 100
No. 50	10 to 40	20 to 40
No. 100	0 to 15	10 to 25
No. 200	0 to 5	0 to 10

C. Physical properties.

	Maximum
Loss, sodium sulfate soundness test	10 %
Aggregations of soil, silt, etc. by weight	0.5 %

When using mortar made with untreated sand, testing for the effect of organic impurities on strength of mortar must show a compressive strength no less than 95 percent of the compressive strength of mortar made with treated sand.

703.04 Aggregate for Asphalt Concrete Base (301 and 302).

A. Provide coarse aggregate for asphalt concrete base used in combination with rigid pavement consisting of CCS, gravel, or crushed ACBFS.

Provide coarse aggregate for asphalt concrete base used in flexible pavements consisting of CCS, gravel (see note [1] in table below), or crushed ACBFS. Provide fine aggregate for asphalt concrete base consisting of natural sand or sand manufactured from stone, gravel, or ACBFS. The City will allow the use of Crushed Steel Slag (OH, EAF or BOF) conforming to 703.01.E and 401.03 for coarse and fine aggregate in asphalt concrete base used in flexible pavements.

B. Physical properties.

Percent of wear, Los Angeles test, maximum (CCS or washed gravel)	50 %
Unit weight, compacted, minimum (slag)	65 lb/ft^3
Loss, sodium sulfate soundness test, maximum	15 %
Percent by weight of fractured pieces (one or more faces), minimum	40 %
Micro-Deval Abrasion Loss test, maximum (for coarse aggregate gravel only)	22 % [1]

[1] For MD values greater than the specification limit, conform to ODOT Supplement 1010.

Do not exceed the following percentages of deleterious substances:

Material Type	Percent by Weight
Soft pieces	3.0
Coal and lignite	1.0
Clay lumps	0.25
Pieces having a length greater than 5 times the average thickness	15
Shale and shaly material	2.5
Chert that disintegrates in 5 cycles of the soundness test	2.5

703.05 Aggregate for Asphalt Concrete (Intermediate and Surface Courses), Prime Coat (408), and Microsurfacing (421).

A. Fine Aggregate.

1. Provide fine aggregate consisting of natural sand or sand manufactured from stone, gravel, ACBFS or, for intermediate courses only, steel slag (OH, EAF or BOF) conforming to 703.01.E and 401.03.

2. Sieve analysis.

Standard 703.05 Gradation

Sieve Size	Total Percent Passing
3/8 inch	100
No. 4	90 to 100
No. 8	65 to 100
No. 16	40 to 85
No. 30	20 to 60
No. 50	7 to 40
No. 100	0 to 20
No. 200	0 to 10

Screenings

Sieve Size	Total Percent Passing
3/8 inch	100
No. 4	85 to 100
No. 100	10 to 30

3. Physical properties.

	Maximum
Loss, sodium sulfate soundness test	15 %
Aggregations of soil, silt, etc., by weight	0.5 %

B. Coarse Aggregate.

1. Provide coarse aggregate consisting of CCS, crushed ACBFS, washed gravel, or for intermediate courses only, steel slag (OH, EAF or BOF) conforming to 703.01.E and 401.03.

2. Physical properties.

Percent of wear, Los Angeles test, maximum (CCS or washed gravel)	40 %
Unit weight, compacted, minimum (slag):	
Asphalt Concrete, and 408	70 lb/ft^3
Loss, sodium sulfate soundness test, maximum:	
Asphalt Concrete	12 %
421	15 %
Percent by weight of fractured pieces (one or more faces), minimum	40 %
Micro-Deval Abrasion Loss test, maximum (for gravel only)	20 % [1]

[1] For MD values greater than the specification limit, conform to ODOT Supplement 1010.

Do not exceed the following percentages of deleterious substances:

Material Type	Percent by Weight
Soft pieces	3.0
Coal and lignite	1.0
Clay lumps	0.25
Amount finer than No. 200 sieve	3.0
Pieces having a length greater than 5 times the average thickness	15
Shale and shaly material	2.5
Limonitic concretions	2.5
Alkali	2.5
Chert that disintegrates in 5 cycles of the soundness test	2.5

C. General Requirements for Fine Aggregate. For fine aggregate calculate each individual sieve fraction soundness loss and ensure that the fractional size does not exceed 13.0 percent for all surface courses, intermediate courses and any asphalt concrete course directly below an open graded friction course.

703.06 Sand Cover (407 and 408).

A. Furnish sand cover consisting of natural sand or sand manufactured from stone or ACBFS.

B. Sieve analysis.

Sieve Size	Total Percent Passing
No. 4	90 to 100
No. 50	7 to 40
No. 200	0 to 10

703.07 Mineral Filler.

A. Furnish mineral filler consisting of limestone dust, portland cement, or other inert mineral matter. Provide a thoroughly dry mineral filler free from lumps.

B. Sieve analysis.

Sieve Size	Total Percent Passing
No. 30	100
No. 50	95 to 100
No. 200	65 to 100

703.08 Aggregate for Pipe Bedding and Initial Backfill.

Provide No. 57 coarse aggregate, as specified in 703.01, consisting of washed gravel, or CCS.

Do not use RPCC for any bedding or initial backfill materials.

Do not use reclaimed asphalt concrete for any bedding or initial backfill materials.

703.10 Screenings.

A. Furnish screenings for No. 10 size gravel, or stone. Provide crushed material, when specified, crushed from material larger than the 1/2-inch sieve.

B. Physical properties.

	Maximum
Loss, sodium sulfate soundness test	15 %

703.11 Structural Backfill. Furnish structural backfill consisting of CCS, gravel, natural sand, sand manufactured from stone, foundry sand, or RPCC (Type I only).

Do not use RPCC for any bedding or initial backfill materials.

Do not use RPCC as backfill material for any metallic pipe.

Do not use reclaimed asphalt concrete for any bedding or backfill materials.

Use foundry sand if the material meets these requirements and meets the requirements of the Ohio EPA, Division of Surface Water, Policy 400.007 "Beneficial use of Non-Toxic Bottom Ash, Fly Ash and Spent Foundry Sand and Other Exempt Waste," and all other regulations. Ten days before using foundry sand on the project, submit written permission from the Ohio EPA to the Engineer. Instead of written permission from the Ohio EPA, the Contractor may elect to have an independent consultant pre-qualified by ODOT in remedial design environmental site assessment review the proposed usage. The consultant will provide all documentation utilized to ensure that the proposed usage is according to all Ohio EPA regulations. Ensure that the consultant coordinates all EPA required meetings, documentation, and testing requirements. Ensure that the consultant certifies this to the City.

A. Structural Backfill Type 1.

1. Furnish Type 1 structural backfill that meets the gradations of Item 304, except 0 to 20 percent may pass the No. 200 sieve.
2. Physical properties.

Percent of wear, Los Angeles test, maximum (CCS or washed gravel)	50 %
Loss, sodium sulfate soundness test, maximum	15 %

Do not exceed the following percentages of deleterious substances:

Material Type	Percent by weight
Shale and shaly material	5.0
Chert, that disintegrates in 5 cycles of the soundness test	5.0

Ensure that the portion of the material passing through the No. 40 sieve has a maximum liquid limit of 25 and a maximum plasticity index of 6.

When using RPCC, ensure that the maximum percentage passing the #200 sieve is 10%.

B. Structural Backfill Type 2.

1. Furnish Type 2 structural backfill that meets the gradation below:

Sieve Size	Total Percent Passing	
	3/4 inch max. size	2 1/2 inch max size
2 1/2 inch		100
1 inch		70 to 100
3/4 inch	100	
3/8 inch	80 to 100	
No. 4	60 to 100	25 to 100
No. 8	45 to 95	
No. 40		10 to 50
No. 50	7 to 55	
No. 200	5 to 15	5 to 15

2. Physical properties:

Percent of wear, Los Angeles test, maximum (CCS or gravel)	50 %
Loss, sodium sulfate soundness test, maximum	15 %

Ensure that the portion of the material passing through the No. 40 sieve has a maximum liquid limit of 25 and a maximum plastic index of 6.

703.13 Coarse Aggregate for Items 305, 306, 451 and 452. In addition to the requirements of 703.02, the following aggregate requirements apply.

For a total combined quantity of the listed items greater than 10,000 square yards, provide size No. 57 or 67 from Table 703.01-1. For a total combined quantity of the listed items less than 10,000 square yards, provide one of the following sizes from Table 703.01-1: No. 7, 78, 8, 57, or 67.

Ensure valid results of freeze thaw-resistance testing as outlined below:

Range of Area under Curve Average Total Percent Expansion [1]	Status of Source Approval
0.000 to 0.010	Valid for four years from date approved [2]
0.011 to 0.020	Valid for two years from date approved [2]
0.021 to 0.030 [4]	Not Approved, one retest allowed [3]
> 0.030 [4]	Not Approved, no retesting allowed [3]

[1] As measured at 350 cycles.

[2] The City may require a retest of freeze-thaw resistance before the original expiration date if quality control testing determines a notable change in the properties of the aggregate originating from the affected source. The Laboratory will make the determination to retest.

[3] Except as noted, the City will not retest the material unless the producer of the material sends a written request to the City with substantiation that the producer made significant changes in operation (e.g., new processing equipment, material from a new ledge, etc.).

[4] If the average total percent expansion is greater than 0.020, but the durability is greater than or equal to 100, the City may accept the source for two years.

The Laboratory will maintain a list of approved sources.

703.14 Non Pavement Open-Hearth, Electric Arc Furnace, and Basic Oxygen Furnace Steel Slag Aggregate Use. Provide steel slag according to the following requirements.

1. Non-confined Applications. When using OH, EAF, and BOF slag in applications with unconfined steel slag, ensure that the slag meets the requirements in 703.14.A (deleterious substances and crushing) and 703.14.B (aging and stockpiling requirements). The City will allow use of recycled steel slag from City or non-City projects in applications with unconfined recycled steel slag.

2. Confined Applications. When using OH, EAF, and BOF slag in applications with unconfined steel slag, ensure the steel slag meets all requirements of 703.14. The City will not allow use of recycled steel slag from City or non-City projects in confined applications.

A. Deleterious Substances (soft pieces). Deleterious substances include soft lime, lime oxide, or magnesia agglomerations or any foreign materials prone to rapid disintegration under construction processing and weathering conditions.

Furnish steel slag with less than 3 percent deleterious substances (soft pieces) by weight. The City will use ODOT Supplement 1029 (hand crushing of soft pieces) to determine the soft pieces. The City will not allow crushing of steel slag.

B. Aging and Stockpiling Requirements. Stockpile and age all steel slag as follows:

1. Grade and stockpile the material into maximum size piles of 25,000 ton. Before and during the stockpiling operation, add water to these materials to provide a uniform moisture content not less than their absorbed moisture. Maintain the stockpile in a moist condition during the required stockpiling period.

2. Ensure that the producer mixes the stockpile when the outside surface of the pile has crusted over. The City will inspect the stockpile every 2 months to ensure no crusting occurs. Do not mix frozen stockpile material. Suspend the aging period for stockpiles frozen for more than one month.

3. Ensure an aging period of at least 6 months in duration and start over when adding any new material to the pile during the aging period.

C. Identification of Steel Slag. Provide clear, definitive, and undisputable identification of the proposed material as steel slag.

Obtain evidence from the producer that certifies the material as steel slag and show to the City. Provide information consisting of, but not limited to, the following:

1. Steel producer.
2. Production dates.
3. Production rates.
4. Stockpiling dates.
5. Type of steel furnace(s).
6. All known City and non-City projects where the material was previously used.

The City will allow the Contractor to supplement this identification of steel slag and the source by other information approved by the City or by using 10 years of good performance data. Ensure that the producer submits to the City projects where contractors used the steel slag used without expansion or tufa problems. The City will review the above projects as part of the identification approval process.

D. Tufa Performance Verification of Steel Slag. The City defines tufa as a precipitate form of calcium carbonate that can clog up the underdrain systems. Some steel slag sources clog up underdrain systems and some do not. Base tufa performance verification on field performance and City's inspection of the underdrain systems.

Verify tufa performance.

Ensure that the producer submits past projects at least 10 years old that used the proposed steel slag source to the City. The City may consider projects less than 10 years old for tufa performance verification if the City determines that the project used steel slag 10 years old or greater. Ensure the producer supplies the City with construction plans with the underdrains and underdrain outlets marked on the plans, or other suitable method, approved by the City, showing the underdrain system. Ensure the producer marks the underdrain outlets in the field for inspection. The City will inspect the underdrain systems for tufa deposits. If the City finds tufa deposits in the outlets or in the underdrain system, the City will reject the steel slag source.

E. Expansion Testing of Steel Slag. After meeting the aging and stockpiling requirements, expansion testing is required for steel slag.

Perform expansion testing according to Pennsylvania Department of Transportation PTM No. 130, the ODOT equivalent to this test or expansion testing acceptable to the City.

Ensure that the producer hires an independent AASHTO accredited and City approved laboratory to perform at least half of the expansion testing. The City will allow the producer to perform up to half of the required expansion testing using the producer's laboratory. The Laboratory will observe the expansion testing and approve each independent and producer laboratory.

Perform expansion testing for every 2500 tons or fraction thereof of the material stockpiled in accordance with 703.14.B. For steel slag less than 10 years old, retain a split portion of the expansion sample. Reduce the split sample to 5 lbs and test for total percent MgO by X-Ray florescence and total percent periclase (hard burned MgO) by X-Ray diffraction.

The City will allow a maximum allowable total expansion for each test of no less than 0.50 percent. If any one test fails in the stockpile, the City will reject the entire stockpile. When sampling for expansion, ensure that the producer notifies the City at least 48 hours before the sampling. The City will verify that the sample came from the correct stockpile and take independent split samples, if required.

Submit the expansion test data and a suitably presented summary of the expansion test data to the City for approval. Submit X-Ray florescence and X-Ray diffraction data to the City. The City reserves the right to perform independent testing to verify the laboratory results at any time.

The City expansion test data takes precedence over the producer or independent laboratory expansion testing results in the event of a conflict. The City will make the final determination on all conflicting data.

If the material fails the expansion testing, then stockpile the material for a minimum of 2 additional months from the date of last sampling and retest for expansion. The City will only approve materials that pass the expansion test for use.

703.16 Suitable Materials for Embankment Construction. The City will allow use of natural soil, natural granular material, granular material types, slag material, brick, shale, rock, random material, RAP, RPCC, or PCS as further defined below, in embankment construction. The Engineer will submit samples of soils not identified from the plan subsurface investigation, from borrow sources or materials appearing questionable in the field.

Furnish RPCC with the reinforcing steel cut to a maximum length of 1 inch outside the pieces.

Ensure that pieces of RAP do not exceed 4 inches in the largest dimension.

Furnish steel slag according to 703.14.

When using steel slag, RPCC, or RAP, completely blend it with at least 30 percent natural granular material.

When using coal, completely blend it with natural soil or natural granular materials. Make at least 90 percent of the blend natural soil or natural granular materials.

A. Natural Soils. Furnish natural soils as defined in 203.02.I and classified as City Group Classifications A-4-a, A-4-b, A-6-a, A-6-b, and A-7-6 as further defined below: Furnish soils with a maximum dry density of at least 90 pounds per cubic foot.

Do not use soils having a liquid limit in excess of 65 or soils identified as City Group Classifications A-5, or A-7-5 in the work.

B. Granular Embankment Materials. Furnish natural granular materials as defined in 203.02.H and classified as City Group Classifications A-1-a, A-1-b, A-3, A-3-a, A-2-4, A-2-6, or A-2-7.

Do not use granular material classified as A-2-5.

C. Granular Material Types. Furnish CCS, gravel, durable sandstone, durable siltstone, or blended natural soil or natural granular materials blended with OH, BOF, EAF, or RPCC as detailed above. Furnish durable sandstone and siltstone with a slake durability index greater than 90 percent according to ASTM D 4644.

Except for GS, furnish the following gradations for the granular material types, by weight:

1. Granular Material, Type A. Furnish material having less than 25 percent by weight of the grains or particles passing the No. 200 sieve.

2. Granular Material Type B. For Item 204, furnish the gradation of Item 304, 411, or 617. For Item 203, furnish the gradation of Item 304, 411, or 617 except the City will allow 0 to 20 percent to pass the No. 200 sieve.

3. Granular Material Type C. Furnish well graded material that meets the following gradation:

Sieve Size	Total Percent Passing
3 inch	100
2 inch	70 to 90
1/2 inch	30 to 60
No. 200	0 to 13

4. Granular Material Type D. Furnish the gradation of 100 percent passing the 8 inch sieve, less than 60 percent passing the 3 inch sieve, less than 40 percent passing the 3/4 inch sieve, and 0 to 20 percent passing the No. 200 sieve.

5. Granular Material Type E. Furnish any of the coarse aggregates from No. l through 67 inclusive on Table 703.01-1.

6. Granular Material Type F. Furnish material according to the following:

   a. Well graded material.
   b. A gradation with a top size from 8 inches to 3 inches and a bottom size of No. 200 sieve.
   c. An evenly graded material between the top and bottom size.
   d. Compactable, stable, and serves the intended use.

D. Shale. Furnish shale as defined in 203.02 and as further defined below. Test shale for durability to classify the shale as durable or nondurable shale. The Engineer will test the shale according to the following procedure:

1. The Engineer will obtain a piece of shale that is typical and representative of the rest of the shale. The size of the piece should be about 6 inches diameter. If the City cannot obtain a 6-inch diameter sample, the City will classify the shale as nondurable shale.

2. The Engineer will place the piece of shale in a bucket of water. The Engineer will examine the deterioration or slaking of the shale after 48 hours. If the shale has deteriorated, then the shale is nondurable.

3. If the shale has not deteriorated after being in water for 48 hours, then break down the shale over a 3/4 inch sieve by hand pressure. If 75 percent or less of the shale is retained on the 3/4 inch, then the shale is nondurable.

4. If more than 75 percent of the shale is retained on the 3/4 inch sieve or, then perform a field test for durability. The field test for durability consists of compacting the shale with six passes of a steel drum roller which has a minimum compaction force of 500 pounds per lineal inch of roller drum width. Provide documentation to the Engineer to verify the roller meets the compaction force requirement.

   a. If more than 40 percent of the shale breaks down, by visual inspection, then the shale is nondurable.

   b. If less than 40 percent of the shale breaks down, by visual inspection, then the shale is durable.

703.17 Aggregate Materials for Item 304. Furnish aggregate that is CCS, crushed gravel, crushed ACBFS, or steel slag.

Determine aggregate acceptance before incorporation into the work based on samples taken from stockpiles.

A. Gradations. Furnish CCS and crushed gravel that meets the following gradation:

Sieve Size	Total Percent Passing
2 inch	100
1 inch	70 to 100
3/4 inch	50 to 90
No. 4	30 to 60
No. 30	9 to 33
No. 200	5 to 15 [1]

[1] Furnish steel slag that has 0 to 10 percent passing through the No. 200 sieve

Furnish gravel used under Item 304 that is crushed from material retained on the 1/2 inch sieve.

B. Physical Properties. Furnish CCS and crushed gravel that meets the physical property requirements:

Percent of wear, Los Angeles test, maximum (CCS or crushed gravel)	50 %
Loss, sodium sulfate soundness test, maximum	15 %
Percent by weight of fractured pieces (one or more faces), minimum	90 % [1]

[1] Does not apply to steel slag

Ensure deleterious substances in CCS and crushed gravel do not exceed the following:

Material Type	Percent by weight
Shale and shaly material	5.0
Chert, that disintegrates in 5 cycles of the soundness test	5.0

Ensure a maximum liquid limit of 25 and a maximum plasticity index of 6 for the portion of the material passing through the No. 40 sieve.

703.18 Materials for Item 410, 411, and 617. Furnish CCS, gravel, RPCC, or RAP for materials.

If using RPCC and RAP, provide the following information:

1. Specification item that the material was originally constructed under.
2. The applicable material requirements of the original construction item.

If the original construction requirements meet or exceed the requirements of this specification, then the City may waive the shale, sodium soundness and Los Angeles abrasion test for RAP and RPCC. The City will not require plastic index and clay requirements for RAP. Use RPCC free of steel.

A. Gradations. Use the following gradations for Item 410, 411, and 617.

Furnish materials for Item 410 according to one of the following gradations:

Sieve Size	Type A	Type B	Type C
	Total Percent Passing		
1 1/2 inch	100	100	Size No. 4 or 57 from Table 703.01-1
1 inch	90 to 100	75 to 100	
3/4 inch	60 to 100	60 to 100	
3/8 inch	40 to 60	35 to 75	
No. 4	15 to 30	30 to 60	

Furnish materials for Item 411 according to the following gradation:

Sieve Size	Total Percent Passing
1 1/2 inch	100
1 inch	75 to 100
3/4 inch	60 to 100
3/8 inch	35 to 75
No. 4	30 to 60
No. 30	7 to 30
No. 200	3 to 15

Furnish materials for Item 617 according to the following gradation:

Sieve Size	Total Percent Passing
1 inch	100
3/4 inch	60 to 100
3/8 inch	35 to 75
No. 4	30 to 60
No. 30	9 to 33
No. 200	0 to 15

B. Physical properties.

	Item 410	Item 411	Item 617
Percent of wear, Los Angeles test, maximum	50 %	–	–
Loss, sodium sulfate soundness test, maximum	–	15 %	–
Percent by weight of fractured pieces (one or more faces), minimum	–	–	90 %
Gravel used, portion retained on a No. 4 sieve (one or more faces) minimum crushed	–	40 %	–
Maximum plasticity index of material passing No. 40 sieve	–	6	–

Do not exceed the following percentages of deleterious substances:

Material Type	Percent by weight		
	Item 410	Item 411	Item 617
Shale and shaly material	–	5 % [1]	12 %
Clay	10 %	–	–

[1] Where the major portion of the material in a coarse aggregate, from a source on record at the Laboratory, shows the characteristics of acquiring a mud-like condition when tested for soundness, test it for soundness and ensure a maximum loss of no more than 5 percent.

703.19 Rock and Aggregate Materials for Item 601.

A. Crushed Aggregate Slope Protection and Filter Aggregate for Dump Rock Fill. Furnish crushed gravel, limestone, sandstone, or RPCC for crushed aggregate slope protection and filter aggregate for dump rock fill.

Furnish Size No. 1 or 2 from Table 703.01-1, or according to the following gradation for crushed aggregate slope protection:

Sieve Size	Total Percent Passing
4 inch	100
3 1/2 inch	90 to 100
2 1/2 inch	25 to 90
1 1/2 inch	0 to 25
3/4 inch	0 to 10

For a filter for rock channel protection, use Size No. 3 or 4 from Table 703.01-1.

Physical properties.

Percent of wear, Los Angeles Abrasion Test, maximum (except for ACBFS)	50 %
Loss, sodium sulfate soundness test, maximum (except for RPCC)	15 %
Percent by weight of fractured pieces minimum (CCS or gravel)	90 %
Loss for RPCC, AASHTO T 103 Soundness of Aggregates by Freezing and Thawing	20 % [1]

[1] Use Method C using 25 cycles.

B. Dumped Rock Fill and Rock Channel Protection. Furnish gravel, broken recycled portland cement concrete (RPCC), broken sandstone, broken siltstone, and broken limestone for dumped rock fill and rock channel protection. Furnish sandstone, siltstone, and limestone free of laminations, seams, and fractures, or injury due to blasting.

Except for RPCC, test for soundness according to ASTM D 5240. Use materials having a maximum 30 percent single slab loss and a maximum 20 percent cumulative loss. Ensure a minimum of 8 inch slab heights and lengths. For RPCC, test for soundness according to AASHTO T 103 as stated in 703.18.A.

The City may waive testing when the stone comes from a source with a known durability history.

Do not use thin, slab-like pieces, or any pieces having a dimension larger than 36 inches. Do not use RPCC with reinforcing steel protruding more than 1 inch beyond the outside surface of the concrete pieces.

Furnish dumped rock fill and rock channel protection materials consisting of the four material types defined below:

1. Type A material has at least 85 percent of the total material by weight larger than an 18-inch but less than a 30-inch square opening and at least 50 percent of the total material by weight larger than a 24-inch square opening. Furnish material smaller than an 18-inch square opening that consists predominantly of rock spalls and rock fines free of soil.

2. Type B material has at least 85 percent of the total material by weight larger than a 12-inch but less than a 24-inch square opening and at least 50 percent of the total material by weight larger than an 18-inch square opening. Furnish material smaller than a 12-inch square opening that consists predominantly of rock spalls and rock fines free of soil.

3. Type C material has at least 85 percent of the total material by weight larger than a 6-inch but less than an 18-inch square opening and at least 50 percent of the total material by weight larger than a 12-inch square opening. Furnish material smaller than a 6-inch square opening that consists predominantly of rock spalls and rock fines free of soil.

4. Type D material has at least 85 percent of the total material by weight larger than a 3-inch but less than a 12-inch square opening and at least 50 percent of the total material by weight larger than a 6-inch square opening. Furnish material smaller than a 3-inch square opening that consists predominantly of rock spalls and rock fines free of soil.

ITEM 704 MASONRY UNITS

704.01 Clay or Shale Brick.
704.02 Concrete Brick.
704.03 Concrete Masonry Blocks.

704.01 Clay or Shale Brick. Furnish clay or shale brick conforming to ASTM C 32, with the following modifications:

4.1 Furnish bricks of such size and shape as to allow incorporation in the structure in conformance with the specified dimensions of the structure.

6.1 Furnish materials according to the City's QPL.

704.02 Concrete Brick. Furnish concrete brick according to ASTM C 55, with the following modifications:

4.1.1 and 4.1.2 Use cement conforming to Item 701 Portland Cement.

4.2 Use aggregate that conforms to the quality requirements of 703.02.

8.1 Furnish materials according to the City's QPL.

8.2 Sample and test the brick according to ASTM C 140. Furnish bricks of such size and shape as to allow incorporation in the structure in conformance with the specified dimensions of the structure. Furnish bricks with a rectangular cross-section with square corners and with plain surfaces for the ends, edges, and one face.

704.03 Concrete Masonry Blocks. Furnish concrete masonry blocks conforming to ASTM C 139, with the following modification:

4.1.1 and 4.1.2 Use cement conforming to Item 701 Portland Cement.

7.1 Furnish materials according to the City's QPL.

7.2 Furnish blocks of such size and shape as to allow incorporation in the structure in conformance with the specified dimensions of the structure.

ITEM 705 CONCRETE INCIDENTALS

705.01 Glass Fiber Reinforced Polymer (GFRP) Dowel and Deformed Bars.
705.03 Preformed Fillers.
705.04 Hot Applied Joint Sealer.
705.05 Burlap Cloth.
705.06 Sheet Materials for Concrete Curing.
705.07 Liquid Membrane-Forming Compounds for Curing Concrete.
705.10 Air-Entraining Admixtures
705.11 Preformed Elastomeric Compression Joint Seal for Concrete.
705.12 Chemical Admixture for Concrete.
705.13 Neoprene Sheeting.
705.15 High Molecular Weight Methacrylate (HMWM) Resin.
705.20 Non Shrink, Non Metallic Materials.
705.21 Quick Setting Concrete Mortar.
705.22 Nonshrink Mortar.
705.23 Concrete Sealers.
705.24 Soluble Reactive Silicate.
705.25 Gravity-Fed Resin.
705.26 Epoxy Injection Resin.

705.01 Glass Fiber Reinforced Polymer (GFRP) Dowel and Deformed Bars. Furnish round and straight fiber reinforced polymer (GFRP) dowel bars. Furnish deformed GRFP bars meeting the material requirements of ACI 440.6. Ensure resin used to manufacture the GFRP bars consists of an epoxy vinyl ester resin. Ensure the glass fiber used is ECR glass which meets ASTM D578. Ensure that the minimum glass fiber content is 70 percent by weight. Furnish dowels and deformed bars of a type meeting the dimensional requirements of the standard drawings. Provide certified test data according to 101.03 with each shipment.

705.03 Preformed Fillers. Furnish preformed fillers according to AASHTO M 153, ASTM D8139, or ASTM D7174.

Furnish materials according to the City's QPL.

705.04 Hot Applied Joint Sealer. Furnish hot applied joint sealer conforming to ASTM D 6690, Type II. Use this material as the primer for Type 3 membrane.

705.05 Burlap Cloth. Furnish burlap cloth according to AASHTO M 182, Class 2.

705.06 Sheet Materials for Concrete Curing. Furnish sheet materials conforming to ASTM C171 for moisture loss and reflectance only.

705.07 Liquid Membrane-Forming Compounds for Curing Concrete. Furnish liquid membrane-forming compounds conforming to ASTM C 309, with the following modification:

5.3 In addition - provide liquid membrane-forming compounds with a minimum solids content of 25%.

6.1 Water Retention – Provide a liquid membrane-forming compound with a water loss of not more than: 0.15 kg/m^2 @ 24 hours and 0.40 kg/m^2 @ 72 hours, when tested in accordance with 10.1.

7.1 Reflectance – Provide a Type 2 curing compound with a minimum daylight reflectance of 65%.

10.4 In addition - Mix Type 2 curing compound until uniform in color and consistency, and then pour into a glass graduated cylinder (Kimax 150 ml) to the 150 ml mark. The Type 2 curing compound should have a rate of settling such that its uniformly white portion as visible to the eye is not less than 145 ml at 2 hours and not less than 125 ml at 24 hours after filling the Kimax cylinder. Perform the test at 73.0 ± 3.5 ºF. During this test, the glass cylinder should be stoppered and left undisturbed.

11.1 In addition, equip the containers for Type 2 white pigmented liquid membrane forming compounds with mechanical agitators. Assign each container, in any batch or lot, a number as the container is being filled.

Furnish materials according to the City's QPL.

705.10 Air-Entraining Admixtures. Provide air-entraining admixtures conforming to AASHTO M 154. Conform to City Supplement 1001 for approval.

Furnish materials according to the City's QPL.

705.11 Preformed Elastomeric Compression Joint Seal for Concrete.

A. General. Provide preformed elastomeric compression joint seal conforming to ASTM D 2628, with the following modifications:

5.1 Provide the size and design as shown on the plans.

7.2 The Engineer will perform inspection at the project site.

7.3 If sampled, provide a minimum of 3 feet, with all manufacturers' markings.

12.1 In addition, provide markings every 1 foot. Use lubricants recommended by the seal manufacturer to install preformed compression seals.

B. Qualification. Obtain City approval of each design, shape, width, depth, web, and shell thickness before use. Submit drawings of the seals showing all dimensions and dimension tolerances and weight per foot with the request for approval.

Furnish materials according to the City's QPL.

705.12 Chemical Admixture for Concrete. Provide chemical admixtures conforming to ASTM C 494 with a minimum relative durability factor of 90.

Furnish materials according to the City's QPL.

705.13 Neoprene Sheeting. Provide material conforming to the following:

Test Description	Specification	Requirement
Thickness (inch)	ASTM D751	0.094±0.01
Breaking Strength, Grab (lb)	ASTM D751	700 × 700 (long. × trans.)
Adhesive Strip, 1" wide × 2" long (lb)	ASTM D751	9
Burst Strength (psi)	ASTM D751	1400
Heat Aging, 70 hr., 212 ºF, 180 º bend without cracking	ASTM D2136	No cracking of coating
Low temperature brittleness, 1 hr., -40 º F, bend around ¼" mandrel	ASTM D2136	No cracking of coating

Furnish material according to the City's QPL.

705.15 High Molecular Weight Methacrylate (HMWM) Resin. Provide low viscosity, non-fuming high molecular weight methacrylate (HMWM) resin conforming to the following:

Viscosity	Less than 25 cps (Brookfield viscometer, Model RVT with UL adaptor or Model LVF, # spindle and UL adaptor C @ 77 °F (ASTM D 2849)
Density	Greater than 8.4 lb/gal Ca 77 °F (ASTM D 2849)
Flash Point	Greater than 200 °F (PenskyMartens CC) (ASTM D 93)
Vapor Pressure	Less than 1.0 mm Hg C @ 77 °F (ASTM D 323)
TG (DSC)	Greater than 135 °F (ASTM D3418)
Shelf Life	Must be 1 year minimum at manufacturers recommended environmental considerations
Gel Time	Greater than 40 min, 100 g mass (ASTM D 2471) (thin film)
Percent Solids	Greater than 90% by weight
Bond Strength	Greater than 1500 psi (ASTM C 882)

Furnish materials according to the City's QPL.

705.20 Non Shrink, Non Metallic Materials. Provide anchoring materials for installing anchor bolts, dowels and similar material in concrete which are non-shrink, 100% solids, two part (resin and hardener), fast setting, and moisture insensitive.

A. Provide certified test data according to 101.03 showing compliance with the following requirements. Include manufacturer's installation and application requirements.

Test Description	Specification	Requirements	Notes
Bond Strength (dry)	ASTM C882	2 day, Min. 1800 psi	Average of three samples [1]
Bond Strength after subjected to 300 cycles freeze/thaw testing	ASTM C882 specimens subjected to ASTM C666 Method B testing and the tested conforming to C882	Min. 1600 psi	Average of three samples [1]
Heat Deflection	ASTM D648	7 day, Min. 130 ºF	
Linear Coefficient of Shrinkage	ASTM C531	% Max. 0.005	
Pullout Strength Test (dry)	See procedure below	24 hours, Min. Load 22,500 lbs	Average of three cylinders in dry condition
Pullout Strength Test (wet)	See procedure below	24 hours, Min. Load 22,500 lbs	Average of three cylinders in wet condition

[1] Make a total of six samples under C882. The City will test three of the C882 samples under C666 Method B and those samples tested.

Pullout Strength Test Procedure. As directed by the Engineer, perform pullout strength tests under dry and wet conditions as follows:

1. Dry Condition (epoxy steel)

Cast three concrete test blocks or cylinders, a minimum of 6 inches in width or diameter by 12 inch in depth. Use concrete with a compressive strength of 4000+/- 500 psi at 28-days. Center a 6 3/4 inch deep hole, drilled the diameter required by the manufacturer's requirements for installing a No. 6 rebar, in the block or cylinder by drilling or forming. Dry the hole surfaces and clean the holes following manufacturer instructions. Fill the hole with adhesive materials according to manufacturer recommendations. Insert a No. 6 deformed reinforcing bar 30 inches long, cleaned and degreased, into the hole. Hold and center the bar perpendicular to the concrete surface in the grout-filled hole during the curing period.

2. Wet Condition (epoxy steel)

Cast three concrete test blocks or cylinders, a minimum of 6 inches in width or diameter by 12 inch in depth. Use concrete with a compressive strength of 4000+/- 500 psi at 28-days. Center a 6-3/4 inch deep hole, drilled the diameter required by the manufacturer's requirements for installing a No. 6 rebar, in the blocks or cylinders by drilling or forming. Wet the hole's surfaces prior to applying the anchoring material by filling the hole with water and letting stand for five minutes. Turn the samples over for two minutes to allow the excess water to drain from the hole, Turn all samples over to the upright positions and immediately fill hole with adhesive materials according to manufacturer recommendations. Insert a No. 6 deformed reinforcing bar 30 inches long, cleaned and degreased into the hole. Hold and center the bar perpendicular to the concrete surface in the adhesive-filled hole during the curing period.

Cure Period. Cure the specimen at 77 ± 5 °F for 24 hours.

Pullout Strength Test. Apply an axial load to the bar at a rate of 1/2 inch per minute until the bar pulls out of the specimen, or the concrete block or cylinder cracks or spalls. Record the failure mode and applied load.

B. Provide epoxy materials that conform to ASTM C881, Type IV, Grade 3, Class A, B or C.

Supply the anchoring material in non-reactive containers and with their SDS. Label containers with the name of the product, the manufacturer, the shelf life expiration date, the batch number, quantity, and provide application instructions.

Maintain storage areas between 40 and 100 °F.

Only use materials on the City's QPL.

705.21 Quick Setting Concrete Mortar. Provide prepackaged mortar material that requires the addition of water only.

Only use materials meeting the following criteria:

A. Capable extending 50 percent by dry mortar weight with aggregate meeting the following requirements:

1. Gradation requirements of Table 703.01-1 for No. 8, 89, 9, or a combination thereof.
2. AASHTO M 43, Maximum Passing No. 200 sieve - Not to exceed 0.2 percent.
3. AASHTO T 84 and T 85, Absorption - Not more than 2 percent.
4. AASHTO T 104, Soundness Loss - Not more than 2 percent.
   a. Ensure that the material meets the following requirements:

Test		Type 1	Type 2
Compressive Strength ASTM C 109[2]			
psi	@ 1 Hour	100	2000
	@ 3 Hour	250	---
	@ 24 Hours	2000	5000
	@ 7 Days	---	7000
Compressive Strength ASTM C 39[1],[2]			
psi	@ 1 Hour	100	(2000)
	@ 3 Hour	150	---
	@ 24 Hours	1000	3500
	@ 7 Days	---	6000
Initial Set Time (min) ASTM C 266[2]		5 Minutes	10 Minutes
Bond Strength, ASTM C 882[1]			
psi	@ 24 Hours	1000	1000
	@ 7 Days	1500	1500
Flexural Strength ASTM C 78[1]			
psi	@ 4 Hour	---	200
	@ 3 Day	650	500
Freeze and Thaw ASTM C 666 (use either Procedure B or A) [1]			
Procedure B (350 Cycles) Durability Factor		80%	80%
Procedure A (300 Cycles) Durability Factor		79%	79%

[1] Extend test specimens 50 percent by dry mortar weight with aggregate.

[2] Test the mortar as received with the addition of water. Designate the amount of water on the packing container by the manufacturer.

B. To prequalify the material, put the material in place and obtain a three year material evaluation conforming to ODOT Supplement 1070. The City will prequalify the material if it meets the following criteria at the end of the 3 year rating:

1. Percentage debonding/delamination ≤ 5%
2. Percentage spalling ≤ 5%
3. Mid panel average crack width ≤ 1/16 inch and total length of mid panel cracks ≤ 20 feet total length
4. Edge Cracking/debonding average crack width ≤ 1/16 inch and total length of cracks ≤ 12 feet

Furnish the Laboratory with a certified copy of test results from a recognized laboratory showing compliance with the requirements of this specification for item.

C. Furnish the laboratory written documentation of the method of surface preparation and any primers, adhesives, or activators used in the field test. The City will require the method of surface preparation and any primers, adhesives, or activators used in the field test for subsequent

approval or use. To qualify as a recognized laboratory, the facility must show a record of regular inspections by the Cement and Concrete Reference Laboratory of the National Institute of Standards and Technology.

Provide quick setting concrete mortar packaged in strong moisture resistant paper bags or other suitable containers capable of withstanding shipping, normal handling, and storage without breakage. Provide packaging capable of protecting the material from deterioration when stored in a dry condition for a period of 1 year. Display information regarding the minimum nominal yield and instructions for mixing on each package. Calculate volumetric yield determinations using the manufacturers' recommended water content.

Furnish materials listed on the City's QPL.

705.22 Nonshrink Mortar. Provide nonshrink mortar conforming to ASTM C 1107, with the following modification:

9.1 In addition, provide grout with a fluidity at least equal to a flowable mixture as defined in ASTM C 827, Section 8.2.2 at the maximum water content. Provide grout with a minimum flow of 125 @ 5 drops of the flow table in 3 seconds.

Furnish materials according to the City's QPL.

705.23 Concrete Sealers.

A. Epoxy-Urethane Sealer. Provide an Epoxy-Urethane sealer incorporating a two component cross linked urethane and conforming to the following requirements:

1. Absorption - ASTM C642 (non-air entrained concrete). Proportion and mix concrete according to ASTM C672. Provide sealed concrete that does not exceed 1.0% absorption after 48 hours or 2.0% absorption after 50 days, under total immersion.

2. Scaling Resistance - ASTM C672 A rating of "No scaling" after 100 cycles on the sealed concrete (non-air entrained concrete) as compared to "Severe Scaling" on untreated concrete.

3. NCHRP 244, Series 11 - Cube Test

   3.1 Weight gain - not to exceed 25% of untreated cube

   3.2 Absorbed chloride - not to exceed 25% of untreated cube

4. NCHRP 244, Series IV - Southern Exposure

   4.1 Absorbed chloride - not to exceed 10% of untreated concrete

5. Volatile Organic Compounds (VOC) maximum, ASTM D 3960, 3.33 lbs./gal, as applied

Record and report the application rate (square footage/gallon) of sealer during the tests.

Provide test data from an approved independent testing facility. The sealer manufacturer funds the testing costs.

Furnish the test data, a one quart sample, and the SDS to the City. The City will determine material acceptance.

Furnish materials according to the City's QPL.

B. Non-Epoxy Sealer. Provide a Non-Epoxy sealer conforming to the following requirements:

1. Absorption - ASTM C642 (non-air entrained concrete). Proportion and mix concrete according to ASTM C672. Provide sealed concrete that does not exceed 1.0% absorption after 48 hours or 2.0% absorption after 50 days under total immersion.

2. Scaling Resistance - ASTM C672 A rating of "No scaling" after 100 cycles on the sealed concrete (non-air entrained concrete) as compared to "Severe Scaling" on untreated concrete.

3. NCHRP 244, Series 11 - Cube Test

   3.1 Weight gain - not to exceed 25% of untreated cube

   3.2 Absorbed chloride - not to exceed 25% of untreated cube

4. NCHRP 244, Series IV - Southern Exposure

   4.1 Absorbed chloride - not to exceed 10% of untreated concrete

5. Volatile Organic Compounds (VOC) maximum, ASTM D 3960, 3.33 lbs./gal, as applied

Record and report the application rate (square footage/gallon) of sealer during the tests.

Provide test data from an approved independent testing facility.

The sealer manufacturer funds the testing costs.

Furnish the test data, a one quart sample, and the MSDS to the Engineer. The Engineer will determine material acceptance.

Furnish materials according to the City's QPL.

705.24 Soluble Reactive Silicate. Provide a soluble reactive silicate (SRS) that consists of a blend of $Na/K/Fl_xSiO_x$ (sodium, potassium, fluoro or other silicate), surfactants, polymers, and stabilizers capable of thoroughly saturating and sealing concrete. Ensure that the treatment system meets the following performance requirements:

A. Scaling Resistance - Treated concrete that passes ASTM C 672, Scaling Resistance test with a rating of 'No Scaling' after 100 cycles (non-air entrained concrete) as compared to 'Severe Scaling' on untreated concrete.

B. Absorption – Provide treated concrete with an absorption under total immersion not exceeding 1.0 percent after 48 hours or 2.0 percent after 50 days (ASTM C 642, non-air entrained concrete). Proportion and mix concrete in accordance with ASTM C 672.

C. Skid resistance – Do not reduce the skid resistance of treated concrete pavement by more than 10 percent as compared to the same untreated pavement. ASTM E 274 using ASTM E 501 ribbed tire at 40 mph, five test average.

D. AASHTO T 259 as modified. Modify the standard T 259 Resistance of Concrete to Chloride Ion Penetration as follows:

In addition to Section 3.1, intentionally break the specimens to produce a full depth crack through the middle of the slab.

Install Section 3.2 dams around the perimeter of the re-assembled, cracked, concrete specimens. Caulk around the perimeter of the dam to ensure water passage or absorption only through the crack and the concrete. After assembly, measure the crack width at three locations and report the crack width.

Perform the ponding of 3.4 until the 3% solution comes through the specimen's crack. Record and report the time required for the solution to appear through the specimen's crack. Remove the solution from the specimens and re-dry according to 3.3 (T 259).

After drying apply the SRS to the specimen's top surface at the manufacturer's recommended rate of application. Record and report the rate of application. Air dry the SRS coated dammed sample specimens for 7 days. After 7 days, re-perform the ponding with 3% chloride solution until solution comes through the specimen's crack or 14 days. Record the time until the ponded solution comes through the crack.

The City will accept SRS materials with a value of 2 or more when dividing the ponding time before SRS application into the ponding time after SRS application.

Sections 3.5, 3.6, 4.1, 4.2 and 5.1 (of T 259) do not apply.

Provide tests performed by an approved independent testing facility acceptable to the City.

Submit test data, a one quart, sample, a technical data sheet and the MSDS to the Engineer for approval.

Furnish materials according to the City's QPL.

705.25 Gravity-Fed Resin. Provide non shrink, non-metallic resin conforming to ASTM C 881, Type 1, Grade 1, Class B or C and the following:

Provide resin with a maximum viscosity at the lowest allowable temperature of 250 cps. Obtain test data from the manufacturer to verify the viscosity at the lowest temperature for the class the Contractor seeks approval for.

Material Approval. Obtain certified test data from the manufacturer verifying compliance with the above requirements; technical data sheet; current SDS for the material; 1 gallon sample; and a letter certifying that the manufacturer will not alter product formulation without notification to the Engineer.

The Engineer will determine materials acceptance and include in the City's QPL.

Furnish materials according to the City's QPL.

705.26 Epoxy Injection Resin. Provide epoxy injection resin capable of application, positive adherence and strength development when applied to moist or wet surfaces at temperatures of 33 °F and above.

Use products that contain 100% solids material and no non-reactive diluents, solvents or other fillers. Provide materials that meet the following requirements:

A. Provide injection material that meets the requirements of ASTM C 881 Type IV, Grade 1 and Class B or C with a maximum viscosity of 600 cps at the lowest ambient material and substrate temperature the Contractor intends to use.

B. Provide paste materials that meet the requirements of ASTM C 881 Type I, Grade 3 and Class B or C.

Material Approval. Obtain material prequalification from the manufacturer of the materials and submit the following to the Engineer:

A. An Independent certified test data indicating that the materials, when mixed according to the manufacturer's recommendations, meet the requirements listed above.

B. Manufacturer's technical data sheet for the paste and injection materials.

C. MSDS for paste and injection materials.

D. 1 Gallon Sample or 2 kits of the injection materials.

Furnish materials according to the City's QPL.

ITEM 706 CONCRETE AND CLAY PIPE

706.01 Non-Reinforced Concrete Pipe.
706.02 Reinforced Concrete Circular Pipe.

706.03 Reinforced Concrete Pipe, Epoxy Coated.
706.04 Elliptical Reinforced Concrete Pipe.
706.05 Precast Reinforced Concrete Box Sections.
706.051 Precast Reinforced Concrete Three-Sided Flat Topped Culverts.
706.052 Precast Reinforced Concrete Arch Sections.
706.053 Precast Reinforced Concrete Round Sections.
706.06 Perforated Concrete Pipe.
706.07 Concrete Drain Tile.
706.08 Vitrified Clay Pipe.
706.09 Clay Drain Tile.
706.10 Bituminous Pipe Joint Filler.
706.11 Resilient and Flexible Gasket Joints.
706.12 Resilient and Flexible Joints.
706.13 Precast Reinforced Concrete Manhole Riser Sections, Flat Slab Tops, Catch Basins and Inlet Tops, and Portable Barriers.
706.14 Preformed Flexible Joint Sealant.
706.15 Precast Reinforced Concrete Outlets.
706.16 Resilient Connectors between Precast Manhole Riser Sections, Catch Basins, Inlets, and Pipes.

706.01 Non-Reinforced Concrete Pipe. Provide non-reinforced concrete pipe conforming to ASTM C 14, with the following modifications:

5.3 Does not apply.

6.2 Provide cementitious materials conforming to Item 701, except 701.07.

6.3 Provide aggregate conforming to the quality requirements of 703.02.

10.3 Perform external load crushing strength tests with hard rubber blocks on wood strips with plaster of paris bedding fillets.

13 Perform inspection at the project site. Obtain random samples from materials delivered to the project site or at other locations designated by the Laboratory. Provide material manufacturer certification by the Laboratory.

15 Ensure that the markings also include "P" to denote non-reinforced pipe.

Testing Equipment. Ensure that every manufacturer furnishing concrete pipe under these Specifications furnishes all facilities and personnel needed to perform the tests.

706.02 Reinforced Concrete Circular Pipe. Provide reinforced concrete circular pipe conforming to ASTM C 655 with the following modifications:

Provide reinforced concrete pipe that meets the following minimum D-Load:

Size	Minimum D-Load
12 in	2000 lb
15 in	2000 lb
18 in	1250 lb
21 in	1250 lb
24 in	1250 lb
27 in or larger	1000 lb

1. Provide circular reinforced concrete pipe with circular or elliptical reinforcement, with and without quadrant and "S" strip reinforcement.

4. The City will determine acceptability of the pipe design according to Section 10. The City will accept all designs in ASTM C 76, Tables 2 through 5, inclusive, with the 0.01-inch crack D-loads as follows:

ASTM C 76 Table No.	D-Load 0.01-inch Crack
2 (Class II)	1000
3 (Class III)	1350
4 (Class IV)	2000
5 (Class V)	3000

The City will accept all designs in Tables 706.02-1 through Table 706.02-4 with noted 0.01-inch crack and ultimate D-loads. For intermediate D-loads, in Tables 2 through 5 of ASTM C 76 steel areas for a given wall thickness the City will allow interpolation between Tables 2 and 3, 3 and 4, and 4 and 5 for a size and D-load as accepted designs. Use the highest of the concrete strengths listed in the tables. In addition, the City will accept steel area designs interpolated as above between Table 706.02-1 and Table 706.02-2, 36-inch through 108-inch using the higher concrete strength, and interpolation of the circumferential steel between Table 706.02-3 and Table 706.02-4 using the wall thickness and stirrup designs in Table 706.02-4. The Laboratory has the option of accepting pipe manufactured according to an accepted pipe design, according to the basis of acceptance described in Section 4.1.1 or 4.1.2.

Provide reinforced concrete pipe with S-stirrups according to Figure 706.02-1 and the following requirements:

1. Provide steel conforming to 709.08, 709.10, 709.11, or 709.12. Ensure that the wall thickness, amount of circular reinforcement, S-stirrup system, and concrete strength comply with Tables 706.02-2, 706.02-3, and 706.02-4. Ensure that the spacing center-to-center of adjacent inner rings of circumferential reinforcement in a cage does not exceed 4 inches for pipe up to and including pipe having a 4 inches wall thickness or exceed wall thicknesses for larger pipe and in no case exceed 6 inches.

2. Ensure that each line of S-stirrups has a continuous "S" shape extending longitudinally from end to end of the pipe. Ensure that they extend from the inner cage toward the outer surface of the pipe for a distance not less than the minimum amplitude. Ensure that S-stirrups pass around and contact each inside circumferential member of the inner cage. Ensure that each line of S-stirrups lie essentially in a plane passing through the longitudinal axis of the pipe.

3. Where using more than one length of stirrup material per line, make a lap round one circumferential member of the inner cage. Ensure that the ends of "S" shaped stirrups at splices include an outer bend. Do not use more than three lengths of "S" material in a line and ensure a 30-inch minimum length of a section of S-stirrups.

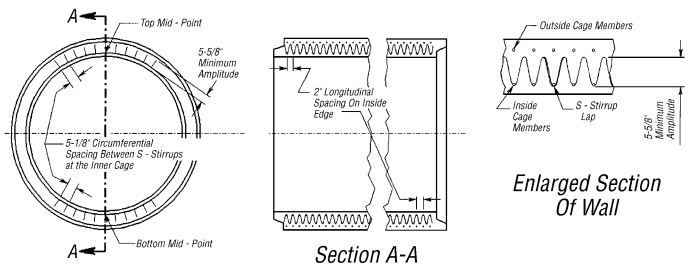

Figure 706.02-1 Illustrative Example of S-Stirrup Support System for 0.01-inch Crack D-load 3000, 102-inch diameter Pipe Minimum Area Per Support 0.053 square inch, 11 Lines Spaced @ 5 1/8 inches. For other classes and sizes, see Tables 706.02-2, 706.02-3, and 706.02-4.

TABLE 706.02-1			
0.01-inch Crack D-Load 1000 Ultimate Strength D-Load 1500			
Internal Diameter of Pipe (in)	**Wall Thickness (in)**	**Circular Reinforcement in Circular Pipe**	
		Inner Cage (in^2/ft of pipe)	**Outer Cage** (in^2/ft of pipe)
Reinforcing Steel 709.11 or 709.12 Only Concrete Strength 4000 psi			
36	4	0.09	0.07
42	4 1/2	0.11	0.08
48	5	0.13	0.09
54	5 1/2	0.16	0.12
60	6	0.19	0.14
66	6 1/2	0.21	0.16
72	7	0.23	0.17
78	7 1/2	0.25	0.19
84	8	0.29	0.21
90	8	0.33	0.24
96	8 1/2	0.37	0.26
Concrete Strength 5000 psi			
102	8 1/2	0.41	0.28
108	9	0.47	0.3
All Permitted Reinforcing Steel Concrete Strength 5000 psi			
114	9 1/2	0.56	0.42
120	10	0.61	0.46
126	10 1/2	0.65	0.49
132	11	0.7	0.52
144	12	0.8	0.6

4.1.1 In addition, test the pipe designs covered by Tables 706.02-1, 706.02-2, 706.02-3, and 706.02-4 and ASTM C 76, Tables 2 through 5, and test interpolated designs by the three-edge bearing method. When the test load on the pipe reaches 115 percent of the required 0.01-inch crack D-load without developing a 0.01-inch or larger crack, the City will accept the test specimen for strength. If any test specimen fails to pass this test, but attained the 0.01-inch crack, continue the test until reaching the ultimate D-load.

4.1.2 In addition, the City will accept pipe 54 inches and larger in diameter covered by Tables 706.02-1, 706.02-2, 706.02-3, and 706.02-4, and ASTM C 76, Tables 2 through 5, and interpolated designs according to Section 12 and the following requirements:

1. When pipe from a plant has been approved by the Laboratory for a specified design and pipe from the same plant has wall and steel area not less than the approved pipe.

2. When it has been established that two or more plants have complied with the above requirements for the class and size under consideration, and the plant under consideration has established compliance with the above requirements for an adjacent size, and the wall and steel area are not less than the pipe tested at the two plants.

6.1.2.1 Provide cement according to Item 701.

6.1.2.2 Provide fly ash according to 701.13.

6.1.3 Provide aggregates conforming to the quality requirements of 703.02.

6.1.5 Provide steel according to 709.08, 709.10, 709.11, or 709.12.

6.2.4 Cast, drill, or otherwise neatly make in the shell of each piece of pipe no more than two holes for the purpose of handling or laying. Taper the holes, unless drilled, and fill the tapered holes with portland cement mortar, or secure precast concrete plugs with portland cement mortar before backfilling. Fill drilled holes with portland cement mortar.

7.1 and 7.3 In addition, perform strength tests using methods described in ASTM C 497.

10.1 For pipe designs covered by Tables 706.02-1, 706.02-2, 706.02-3, and 706.02-4 and ASTM C 76 Tables 2 through 5 provide the number of samples selected as shown in the "Minimum Requirements for Sampling Materials" table for each size, class, and production lot (pipe of the same size and class made from the same materials and by the same process and approximately the same production date) for test.

TABLE 706.02-2

0.01-inch Crack D-Load 1350
Ultimate Strength D-Load 2000

Internal Diameter **of Pipe (in)**	**Wall** Thickness (in)	**Circular Reinforcement in Circular Pipe**		**S-Stirrups**				
		Inner Cage (in2/ft of pipe)	**Outer Cage** (in2/ft of pipe)	**Minimum Area** Per **Support Element** (in2)	**Number** Of **Lines**[1]	**Longitudinal Spacing** (in)	**Circumferential Spacing on Inner Cage** (in)	**Minimum Amplitude**[2] **of Stirrups** (in)
Reinforcing Steel 709.11 or 709.12 Only Concrete Strength 4000 psi								
36	4	0.12	0.09					
42	4 1/2	0.15	0.11					
48	5	0.17	0.12					
54	5 1/2	0.21	0.16					
60	6	0.26	0.20					
66	6 1/2	0.30	0.21					
72	7	0.35	0.24					
78	7 1/2	0.40	0.27					
84	8	0.47	0.30					
Reinforcing Steel 709.11 or 709.12 Only Concrete Strength 5000 psi								
90	8	0.64	0.35					
96	8 1/2	0.80	0.40					
102	8 1/2	0.96	0.44					
108	9	1.07	0.47					
All Permitted Reinforcing Steel, Concrete Strength, 5000 psi								
114	9 1/2	0.69	0.52	0.041	5	2	6 1/8	6 5/8
120	10	0.74	0.55	0.041	5	2	6 1/2	7 1/8
126	10 1/2	0.79	0.60	0.041	5	2	6 7/8	7 5/8
132	11	0.85	0.64	0.041	5	2	7 1/4	8 1/8
144	12	0.97	0.73	0.041	5	2	8	9 1/8

[1] Number of lines in the table indicates the number of longitudinal lines required in each top and bottom portion of the pipe. The area of each support element in a pipe measures as two times the cross-sectional area of the S-stirrups wire used. Ensure an equal number of these lines of S-stirrups on either side of the mid-point of both the top and bottom of the pipe. See Figure 706.02-1.

[2] Measure the amplitude as the overall width of the line of stirrups.

TABLE 706.02-3

0.01-inch Crack D-Load 2000 Ultimate Strength D-Load 3000								
Internal Diameter **of Pipe** (in)	**Wall Thick-ness** (in)	**Circular Reinforcement in Circular Pipe**		**S-Stirrups**				
		Inner Cage (in^2/ft of pipe)	**Outer Cage** (in^2/ft of pipe)	**Minimum Area Per Support Element (in^2)**	**Number of Lines[1]**	**Longitudinal Spacing (in)**	**Circumferential Spacing on Inner Cage (in)**	**Minimum Amplitude[2] of Stirrups (in)**
Concrete Strength, 5000 psi								
78	7 1/2	0.69	0.52	0.029	11	2	4 1/8	4 5/8
84	8	0.74	0.56	0.029	11	2	4 5/8	5 1/8
90	8	0.85	0.63	0.031	11	2	4 5/8	5 1/8
96	8 1/2	0.91	0.69	0.034	11	2	5 1/8	5 5/8
102	8 1/2	1.02	0.77	0.041	12	2	5 1/8	5 5/8
108	9	1.07	0.80	0.045	11	2	5 5/8	6 1/8
114	9 1/2	1.02	0.77	0.048	11	2	6 1/8	6 5/8
120	10	1.10	0.82	0.051	11	2	6 1/2	7 1/8
126	10 1/2	1.17	0.88	0.055	11	2	6 7/8	7 5/8
132	11	1.25	0.94	0.058	11	2	7 1/4	8 1/8
144	12	1.42	1.07	0.065	11	2	8	9 1/8

[1] and [2] Refer to footnotes in Table 706.02-2

TABLE 706.02-4

0.01-inch Crack D-Load 3000 Ultimate Strength D-Load 3750								
Internal Diameter **of Pipe** (in)	**Wall** Thickness (in)	**Circular Reinforcement in Circular Pipe**		**S-Stirrups**				
		Inner Cage (in^2/ft of pipe)	**Outer Cage** (in^2/ft of pipe)	**Minimum Area Per Support Element (in^2)**	**Number of Lines[1]**	**Longitudinal Spacing (in)**	**Circumferential Spacing on Inner Cage (in)**	**Minimum Amplitude[2] of Stirrups (in)**
Concrete Strength 6000 psi								
6	1 3/4	0.07	--					
8	1 3/4	0.07	--					
10	1 3/4	0.07	--					
54	5 1/2	0.86	0.62					
60	6	0.95	0.68					
Concrete Strength 5000 psi								
54	5 1/2	0.64	0.48	0.029	15	2	2 1/8	2 5/8
60	6	0.70	0.53	0.029	14	2	2 5/8	3 1/8
66	6 1/2	0.79	0.59	0.029	13	2	3 1/8	3 5/8
72	7	0.87	0.66	0.029	12	2	3 5/8	4 1/8
78	7 1/2	0.92	0.69	0.031	11	2	4 1/8	4 5/8
84	8	0.99	0.74	0.034	11	2	4 5/8	5 1/8
90	8	1.13	0.85	0.041	11	2	4 5/8	5 1/8
96	8 1/2	1.20	0.90	0.045	11	2	5 1/8	5 5/8
102	8 1/2	1.34	1.00	0.053	11	2	5 1/8	5 5/8
108	9	1.51	1.13	0.063	11	2	5 5/8	6 1/8
114	9 1/2	1.51	1.13	0.064	11	2	6 1/8	6 5/8
120	10	1.62	1.21	0.068	11	2	6 1/2	7 1/8
126	10 1/2	1.73	1.30	0.072	11	2	6 7/8	7 5/8
132	11	1.84	1.38	0.076	11	2	7 1/4	8 1/8
144	12	2.09	1.57	0.085	11	2	8	9 1/8

[1] and [2] Refer to footnotes in Table 706.02-2

11.1 Perform compression tests on cores according to ASTM C 497

11.3 Does not apply.

12 Perform inspection at the project site. Obtain random samples from material delivered to the project site or at other locations designated by the Laboratory.

16 Furnish materials from suppliers certified by the City.

17 In addition, after the capital letter "D," designate the D-load, the design wall thickness in inches expressed as a decimal. Include the symbol "S" on pipe with S-stirrups. For pipe requiring axis orientation without lift holes (i.e., stirrup pipe, quadrant reinforced pipe, elliptically reinforced pipe) mark the centerline of the pipe crown inside and outside with the symbol "TB". Mark pipe with quadrant steel with the symbol "Q". Mark pipe with elliptical reinforcement with the symbol "E". Mark pipe with deformed wire reinforcement required in the design with the symbol "DF".

706.03 Reinforced Concrete Pipe, Epoxy Coated. Provide Type A reinforced concrete epoxy coated pipe conforming to 706.02 and Type B conforming to 706.04, with the following modification:

In the plant, prepare the interior barrel and joint surface areas of the concrete pipe to remove all forms of oil, laitance, and other deleterious materials and then line the pipe with a high-build, polyamide-cured, two-component coal tar epoxy coating, Military Specification DOD-P-23236A (SH). Spray the lining compound to obtain a continuous and relatively uniform and smooth lining with a minimum dry film thickness of 0.03 inch. Provide coated pipe free of surface irregularities such as air bubbles, delamination, lumping, sagging, blistering, pinholing, or porosity, in the coating film.

706.04 Elliptical Reinforced Concrete Pipe. Provide elliptical reinforced concrete pipe conforming to ASTM C 507, with the following modifications:

4.1 Delete Class HE-A. Table 706.04-1 includes additional design requirements.

5.1 The City will inspect and approve all materials, processes of manufacture, and finished pipe. When directed by the Laboratory, the manufacturer will cut holes in sections of the finished pipe for inspection.

6.2.1 Provide cement according to Item 701, except 701.07.

6.2.2 Provide fly ash according to Item 701.

6.3 Provide aggregates conforming to the quality requirements of 703.02.

6.5 Provide steel according 709.08, 709.10, 709.11, or 709.12.

7.2 In addition, manufacture horizontal elliptical pipe HE-II and HE-III using the design requirements of Table 706.04-1.

8.1 Provide three lines of reinforcement of elliptical shape for pipe made in accordance with Table 706.04-1. Provide a 1-inch nominal protective covering of the concrete over the outer and inner lines of reinforcement in the barrel of the pipe subject to the variations permitted in Section 12.5. Securely fasten the third or middle line to, and ensure contact with, the inner line at the vertical axis of the pipe both top and bottom and to the outer line at the horizontal axis on both sides. Measure the length of the middle line as the average of the length of the inner and outer line. Provide an elliptically shaped middle line that runs smoothly between the specified points of contact with the inner and outer lines.

10 Cast, drill, or otherwise neatly make no more than two holes in the shell of each piece of pipe for the purpose of handling or laying. Taper the holes unless drilled, and before backfilling. Fill the tapered holes with portland cement mortar, or secure the precast concrete plugs with portland cement mortar. Fill drilled holes with portland cement mortar.

11.2 Select the specified number of pipe that the City would not otherwise reject under these Specifications, as noted in the "Minimum Requirements for Sampling Materials" table, for the purpose of test at the plant and at random from the lot intended for shipment or at the project site from the pipe delivered. Test pipe according to ASTM C507 Section 5.1.1 except the Laboratory may accept pipe 54 inches and larger in diameter according to ASTM C507 Section 5.1.2 and the following requirements:

1. When the Laboratory approves pipe from a plant for a specified design, the City may approve pipe from the same plant with wall and steel area not less than the approved pipe by means of tests on cores verifying absorption, strength, wall, and steel area.

2. When two or more plants comply with the above requirements for the class and size under consideration and the plant under consideration establishes compliance with the above requirements for an adjacent size, and the wall and steel area are not less than the pipe tested at the two plants.

11.3.1 Use an ultimate load, as determined by ASTM C 497 three-edge bearing method, not less than shown in Tables 1, 2, and 706.04-1 to produce a 0.01-inch crack. The City may waive the ultimate strength test when the test load on the pipe reaches 115 percent of the required 0.01-inch crack D-load without developing a 0.01-inch or larger crack.

11.4 Perform compression tests for satisfying the minimum specified concrete strength requirement from cores drilled from the wall of the pipe. Ensure a core of a diameter that the capped height to diameter or L/D ratio lies between one and two. Secure the cores, prepare for testing, and test by methods prescribed in the appropriate sections of ASTM C 497. Ensure a compressive strength of each core tested equal to or greater than the design strength of the concrete. If a core fails to meet the required strength, test another core from the same pipe. If this core also fails to meet the required strength, the City may reject the pipe. Make additional tests on other pipe to determine the acceptability of the lot. When the cores cut from a section of pipe successfully meet the strength test requirement, ensure that the manufacturer plugs and seals the core holes so that the pipe section meets all of the test requirements of these Specifications.

11.9 Does not apply.

11.10 Does not apply.

14 Perform inspection at the project site. Obtain random samples from material delivered to the project site or at other locations designated by the laboratory.

Use pipe manufacturers certified by the City.

16 In addition, place the plant location on each pipe, and for pipe manufactured to design requirements of Table 706.04-1 place the letter "A" after the pipe class. Provide legible markings indented in the pipe section or painted on with waterproof paint.

TABLE 706.04-1 DESIGN REQUIREMENTS FOR HORIZONTAL ELLIPTICAL PIPE

Equiv. Round Size (inch)	Rise (inch) × Span (inch)	Minimum Wall Thickness (inch)	Minimum Reinforcement (in^2/ft)	
			HE-II	HE-III
			D-Loads	
			0.01 = 1000	0.01 = 1350
			Utl. = 1500	Utl. = 2000
78	63 × 98	8	3 lines totaling 0.87	3 lines totaling 1.23
84	68 × 106	8 1/2	3 lines totaling 0.97	3 lines totaling 1.33
90	72 × 113	9	3 lines totaling 1.03	3 lines totaling 1.43
96	77 × 121	9 1/2	3 lines totaling 1.13	3 lines totaling 1.54
102	82 × 128	9 3/4	3 lines totaling 1.23	3 lines totaling 1.70
108	87 × 136	10	3 lines totaling 1.43	3 lines totaling 1.85
The test load in lb/ft equals D-load x nominal inside span in feet. Concrete strength = 5000 psi.				

706.05 Precast Reinforced Concrete Box Sections. Provide precast reinforced concrete box section conforming to ASTM C 1577, with the following modifications:

Use precast concrete member manufacturers certified by the Laboratory according to City Supplement 1073.

Submit shop drawings according to 501.04 (A).

6.2.1 Provide cement according to Item 701, except 701.07.

6.2.4.9 Provide Carbonate Micro-Fines according to 701.14 and Table 499.03-2.

6.3 Provide aggregates conforming to the quality requirements of 703.02.

6.5 Provide reinforcement according to 709.10 or 709.12. Provide longitudinal distribution reinforcement according to 709.01, 709.10 or 709.12.

7.1 For the following box sizes, span by rise, refer to ASTM C1577: 8x4, 5, 6, 7; 10x5, 6, 7, 8, 9; and 12x4, 6, 8, 10 feet. For the following box sizes, span by rise, refer to ODOT SS940: 14x4, 5, 6, 7, 8, 9, 10; 16x4, 5, 6, 7, 8, 9, 10; 18x4, 5, 6, 7, 8, 9, 10; and 20x4, 5, 6, 7, 8, 9, 10 feet.

9.1 Provide hardened concrete that contains a minimum of 4 percent entrained air for wet-cast sections with spans less than 14 feet and for all sections with spans 14 feet and greater.

9.4 Lift holes are not permitted. Use handling devices that do not require a hole through the box.

10.1 Verify concrete strength using cylinders. Do not ship items before the design strength of the concrete is reached.

11.5 A minimum cover of 1/2 inch over both circumferential and longitudinal reinforcement is required at the mating surfaces of joints.

15 In addition, mark the identification of the plant on each box section. For box sections 14 feet or greater, mark the reinforcing steel areas for the section on each box section. Place the manufacturers' name and required product information on the inside of the box section within the top one-half of the culvert.

706.051 Precast Reinforced Concrete Three-Sided Flat Topped Culverts. Provide precast concrete three-sided flat topped culverts according to ASTM C 1504, with the following modifications:

Provide flat deck culvert structures with a minimum clear span (measured normal to the structure at the bottom of the haunch) of 14 feet and a minimum opening rise (measured from bottom of leg to bottom of deck at the centerline of the structure) of 4 feet; and a maximum clear span of 34 feet and maximum opening rising of 10 feet. Ensure minimum wall and deck thicknesses of 10 inches and 12 inches respectively, measured under the haunch normal to the structure and at the centerline of the span measured perpendicular to the structure.

Use precast concrete member manufacturers certified according to City Supplement 1073.

Ensure that the manufacturer submits design calculations, a structural load rating and shop drawings according to 501.04 (A). Do not produce any units until approved drawings have been submitted to the City. Ensure that the shop drawings include the following:

1. Load rate the structure according to the requirements of Section 900 of ODOT's Bridge Design Manual.
2. All material specifications.
3. All plan view.
4. All elevation view.
5. All headwall and wingwall attachment requirements.
6. All dimensions.
7. All maintenance of traffic phases.
8. All section sizes.
9. All design handling strength.

The manufacturer may modify an approved shop drawing and resubmit according to 501.04 (A).

Ensure that the shop drawings also include the following special information as required:

1. For top mounted guardrail, show the guardrail plate and bolt locations in the plan view with holes a minimum of 6 inches from a joint.
2. For side mounted guardrail, show additional reinforcing details according to the plan details.

6.2.1 Provide cement according to Item 701, except 701.07.

6.2.2 Provide fly ash according to 701.13.

6.2.4.9 Provide Carbonate Micro-Fines according to 701.14 and Table 499.03-2.

6.3 Provide aggregates conforming to the quality requirements of 703.02.

6.4 Use chemical admixtures according to 705.12. Use a corrosion inhibitor unless using epoxy coated reinforcing steel. See the approved list of corrosion inhibiting admixtures on file at the Laboratory. Ensure that the manufacturers recognize that the corrosion inhibitors and admixtures may have an effect on strength, entrained air content, workability, etc. of their concrete mixes. The manufacturer's choice of one of these corrosion inhibitors does not alleviate meeting all design requirements of this structure.

6.4.1 Provide air-entraining admixture according to 705.10.

6.5 Provide epoxy coated reinforcement according to 709.00, Grade 60, or 709.14. In lieu of epoxy coated reinforcement, the City will allow the addition of an approved corrosion inhibiting admixture to the concrete at the approved dosage; and provide reinforcement according to

709.01, 709.03 or 709.05; Grade 60 or 709.08, 709.10, 709.11 or 709.12. Provide epoxy or galvanized coated connections when connecting a precast structural unit into a cast-in-place structural component or between segments of adjacent precast structural units either manufactured as separate units or across construction joints when manufactured as one unit. Provide epoxy coated reinforcement according to 709.00 or 709.14, for connections designed to use reinforcing steel. Provide galvanized coatings according to 711.02, for connections designed to use connection plates, hardware or concrete inserts.

7.1 Design according to *AASHTO LRFD Bridge Design Specifications*, Section 12.14. Include a future wearing surface loading of 60 psf.

7.2 Ensure a minimum of 2 inches of concrete cover dimension over reinforcement in the slab and in the exterior of the leg. Ensure that the interior of the leg reinforcement cover tapers from 1 inch at the bottom of the leg to 2 inches at the bottom of the haunch.

Ensure a minimum cover of 1/2 inch on the ends of longitudinal reinforcement. , Use plastic or epoxy coated steel spacers to position the reinforcement even if using a corrosion inhibiting admixture.

8 Construct the top slab with a keyway joint. The keyway provides a void volume equivalent to that of 12 inches prestressed beam as per ODOT's Standard Drawing PSBD-2-07. Design the joint in the leg sections to produce a shear key or inter-locking joint. Ensure flat, non-adjoining outside legs. Sandblast the joint surfaces to the satisfaction of the City, or use a 2,000 pounds per square inch water blast no more than 14 days prior to shipping. Design that the culvert so that the sections laid together make a continuous line with a smooth interior free of appreciable irregularities, all compatible with the permissible variations of Section 11.

9 Do not apply waterproofing membrane at any location other than the final location shown on the plans.

9.1 Ensure that the aggregate, cement, and water are manufactured in conformance with 499.06, and 499.07.

Ensure that the temperature requirements of 511.08 and 511.15 are met.

Ensure that the proportion of cementitious and carbonate micro-fines material is not less than 564 pounds per cubic yard of concrete.

If used, add the corrosion inhibitor as an aqueous solution. Consider the water in the solution as mixing water for the purpose of determining the water to concrete ratio of concrete.

9.2 Cure the three-sided sections in the forms for the length of time required to obtain the specified minimum design handling strength as defined in the shop drawings. Test a cylinder to check each section's design handling strength. Repeat this test as often as needed. The City will consider only one cylinder passing as proof that the concrete achieved the desired design handling strength requirement. If the shop drawing shows no design handling strengths, then assume 100 percent of the design strength as the minimum handling strength. Ensure that the curing then continues either in or out of the forms until the concrete meets the specified minimum design strength.

9.2.1 To accelerate the cure, the City will allow steam curing using low pressure steam or radiant heat within a suitable insulated enclosure to contain the live steam or heat. Apply the initial steam or heat from two to four hours after the final placement of concrete to allow the initial set to take place. When using retarders, increase the waiting period to 4 to 6 hours. As an alternative, determine the actual time of initial set according to ASTM C 403. Do not start curing until the initial set time.

Maintain a temperature within the curing enclosure of not less than 50 °F during the waiting period. During the initial application of live steam or radiant heat, ensure that the ambient temperature within the curing enclosure increases at an average rate not exceeding 40 °F per hour until reaching the curing temperature.

Do not exceed a maximum curing temperature of 150 °F. Ensure that the Hold the design temperature until reaching the desired design strength. Do not direct the application of live steam on the concrete forms so as to cause localized high temperatures.

9.2.2 Provide water curing according to 511.15 and 511.17, Method A.

9.2.3 Provide membrane curing according to 511.16, Method B.

9.3 Keep all forms in place until meeting the design handling strength.

9.4 Do not make holes for handling or setting. Do not move members before the design handling strength of the concrete is reached, or shipped before the design strength of the concrete is reached. Ensure that the manufacturers possess the equipment needed to handle and transport the pieces without damaging them.

10 Ensure that the hardened concrete contains a minimum of 4 percent entrained air.

10.2.1 Keep the cylinders and matching culvert section together to guarantee the cylinders match with the corresponding culvert section; or, upon agreement by the City, keep the cylinders at a location that provides the same environment as the culvert sections.

10.2.2 For each section of the culvert, produce and mark at least four cylinders in order to ensure identification with the matching culvert section.

10.2.3 Conform to City Supplement 1073 for acceptance.

10.2.3.1 Ensure that cylinder strengths conform to City Supplement 1073.

10.4 Plug the core holes using the same concrete mixture as that used in the section and cured in according to Section 9.2, or by a non-shrink grout that exceeds the concrete design strength.

11 The design in the plan reflects the external top slab elevation of the structure. For a structure supplied with a thicker deck than the plan design, eliminate the difference between the design top slab elevation and the supplied top slab elevation by a reducing the leg length. The City

may approve alternate methods to eliminate the difference between the design top slab elevation and the supplied top slab elevation. The City will not approve a change in the top slab elevation from that shown on the plans.

The plan shows the minimum clear span for the structure. The City will allow the Contractor to provide a clear span greater than that shown. Base the exact footer locations for both the elevation and offset on the manufacturer's shop drawings. Locate the footers to match the centerline of the leg at the bottom of the haunch to the centerline of the footer.

The City will make no additional payment for changes to the project resulting from the manufacturer's dimensional changes in the structure.

Provide sections free of fractures spalls and chips with a smooth and regular finish defined as a 1/4-inch variation within 4 feet.

11.1 Construct walls perpendicular to the slab with a diagonal difference of not more than 0.5 percent.

Build sections within 1/2 inch of the design length. The City will consider the length as the average of the length measured at each side and at the middle of the three-sided section.

11.4 Ensure a maximum variation of 3/8-inch in the position of the reinforcement. Ensure a cover of no less than 2 inches over the reinforcement for the external surface of the top slab. The above tolerances or cover requirements do not apply to mating surfaces at the joint.

11.5 Resubmit any change in reinforcement from the shop drawings for approval.

12 Make repairs according to the City's requirements. The City will not make additional payments for culvert repairs. The City will consider sound, properly finished, and cured repairs as acceptable.

13 Perform inspection at the project site.

Furnish precast concrete components from suppliers certified according to City Supplement 1073.

14 Form seams and slight surface irregularities that are expected from a wood panel forming system will not be cause for rejection. In addition, hairline cracks less than 0.01 inch are not cause for rejection.

15.1 Locate the product marking on the interior of the three-sided section 1 foot below the leg haunch.

Add the product marking upon removal of the forms.

The manufacturer may be required to repeat the product markings before the project is final.

706.052 Precast Reinforced Concrete Arch Sections. Provide precast reinforced concrete arch sections according to ASTM C 1504, with the following modifications:

This item shall consist of manufacturing precast reinforced concrete arch sections for culverts.

Use precast concrete member manufacturers certified according to City Supplement 1073.

Ensure the manufacturer submits design calculations, a structural load rating and shop drawings according to 501.04 (A). Do not produce any units until approved drawings have been submitted to the City. Ensure the shop drawings include the following:

1. Load rate the structure according to the requirements of Section 900 of ODOT's Bridge Design Manual.
2. All material specifications.
3. All plan view.
4. All elevation view.
5. All headwall and wingwall attachment requirements.
6. All dimensions.
7. All maintenance of traffic phases.
8. All section sizes.
9. All design handling strength.

The Contractor may modify an approved shop drawing and resubmit according to 501.04 (A).

Ensure that the shop drawings also include the following special information as required:

1. For top mounted guardrail, show the guardrail plate and bolt locations in the plan view with holes shown as a minimum of 6 inches from a joint.
2. The corrosion inhibitor used, if any. The dosage rate will be as per the manufacturer's recommendation.

6.2.1 Provide cement according to Item 701, except 701.07.

6.2.2 Provide fly ash according to 701.13.

6.2.4.9 Provide carbonate micro-fines according to 701.14 and Table 499.03-2.

6.3 Provide aggregates conforming to the quality requirements of 703.02.

6.4 Use chemical admixtures according to 705.12. Use a corrosion inhibitor unless using epoxy coated reinforcing steel. See an approved list of corrosion inhibiting admixtures on file at the Laboratory. Ensure that the manufacturers recognize the effect on strength, entrained air

content, workability, etc. of the concrete mixes resulting from use of corrosion inhibitors and admixtures. The manufacturer's choice of one of these corrosion inhibitors does not alleviate meeting all design requirements of this structure.

6.4.1 Provide air-entraining admixture according to 705.10.

6.5 Provide epoxy coated reinforcement according to 709.00, Grade 60, or 709.14. In lieu of epoxy coated reinforcement, the Contractor may add an approved corrosion inhibiting admixture to the concrete at the approved dosage; and provide reinforcement according to 709.01, 709.03 or 709.05; Grade 60 or 709.08, 709.10, 709.11 or 709.12. Provide epoxy or galvanized coated connections when connecting a precast structural unit into a cast-in-place structural component or between segments of adjacent precast structural units either manufactured as separate units or across construction joints when manufactured as one unit. Provide epoxy coated reinforcement according to 709.00 or 709.14, for reinforcing steel designed connections. Provide galvanized coatings according to 711.02, for connection designs using connection plates, hardware or concrete inserts.

7.1 Design according to *AASHTO LRFD Bridge Design Specifications*, Section 12.14. Include a future wearing surface loading of 60 psf.

7.2 Ensure a 2-inch minimum concrete cover dimension over the outside circumferential reinforcement. Ensure a 1-1/2-inch minimum of concrete cover dimension over the inside circumferential reinforcement. Ensure a clear distance of no less than 1 inch or more than 2 inches from the end circumferential wires to the ends of the sections. Assemble reinforcement using single or multiple layers of welded wire fabric (three-layer maximum), or using a single layer of deformed billet-steel bars. Use welded wire fabric composed of circumferential and longitudinal wires containing sufficient longitudinal wires extending through the section to maintain the shape and position of reinforcement. The City will allow longitudinal distribution reinforcement of welded wire fabric or deformed billet-steel bars. Ensure that the ends of the longitudinal distribution reinforcement extend no more than 3 inches from the ends of the sections.

Bend the outside and inside circumferential reinforcing steel for the corners of the culvert to an angle approximately equal to the configuration of the culverts outside corner.

7.3 Do not make tension splices in the circumferential reinforcement. For splices other than tension splices, the overlap a minimum of 12 inches for welded wire fabric or deformed billet steel bars. Space the circumferential wires in a wire fabric sheet center-to-center no less than 2 inches or more than 4 inches. For the wire fabric, space the longitudinal wire no more than 8 inches center-to-center. Space the longitudinal distribution steel for either line of reinforcing in the top slab no more than 16 inches center-to-center.

8.1 Construct the sections with butt ends. Make the ends of the sections so that the sections laid together form a continuous line of sections with a smooth interior free of appreciable irregularities, all compatible with the permissible variations in these Specifications. Provide a chamfer on the outside surface at the sections joint to form a void for a 7/8 × 1 3/8-inch flexible plastic gasket 706.14.

9 Do not apply waterproofing membrane on the arch section at any location other than the final location shown on the plans.

9.1 Ensure that the aggregate, cement, and water are manufactured according to 499.06, and 499.07.

Ensure that the temperature requirements of 511.08 and 511.15 are met.

Ensure that the proportion of cementitious and carbonate micro-fines material is not less than 564 pounds per cubic yard of concrete.

If used, add the corrosion inhibitor as an aqueous solution. Consider the water in the solution as mixing water for the purpose of determining the water-cement ratio of concrete.

9.2 Cure the arch sections in the forms for the length of time required to obtain the specified minimum design handling strength as defined in the shop drawings. Test a cylinder to check each section's design handling strength. Repeat this test as often as needed. The City will consider only one cylinder passing as meeting the design handling strength. If the shop drawing shows no design handling strengths, then assume the minimum handling strength as 100 percent of the design strength. Ensure that the curing then continues either in or out of the forms until the concrete meets the specified minimum design strength.

9.2.1 The City will accept steam curing by low pressure steam or radiant heat within a suitable insulated enclosure to contain the live steam or heat as an accelerated cure method. Make the initial application of the steam or heat from 2 to 4 hours after the final placement of concrete to allow the initial set to take place. If using retarders, increase the waiting period to 4 to 6 hours. As an alternative, determine the actual time of initial set according to ASTM C 403. Do not start curing until the actual time to initial set elapses.

During the waiting period, ensure a temperature within the curing enclosure of no less than 50 °F.

During the initial application of live steam or radiant heat, ensure that the ambient temperature within the curing enclosure increases at an average rate not exceeding 40 °F per hour until reaching the curing temperature.

Do not exceed a maximum curing temperature of 150 °F. Hold the design temperature until the concrete has reaches the desired design strength. Do not direct the application of live steam on the concrete forms so as to cause localized high temperatures.

9.2.2 Provide water curing according to 511.15 and 511.17, Method A.

9.3 Keep all forms in place until meeting the design handling strength.

Do not make holes for handling or setting. Do not move members before the design handling strength of the concrete is reached, or shipped before the design strength of the concrete is reached. Ensure that the manufacturers possess equipment necessary to handle and transport the pieces without damaging them.

10 Ensure that the hardened concrete contains a minimum of 4 percent entrained air.

10.2.1 Keep the cylinders and matching culvert section together to guarantee the cylinders stay matched with the corresponding culvert section; or, upon agreement by the City, keep the cylinders at a location that provides the same environment as the culvert sections.

10.2.2 For each section of the culvert, produce and mark at least four cylinders so that they are identifiable with the matching culvert section.

10.2.3 Conform to City Supplement 1073 for acceptance.

10.2.3.1 Ensure that cylinder strengths conform to City Supplement 1073.

10.4 Plug the core holes with the same concrete mix used in the section and cured according to Section 9.2, or by a non-shrink grout that exceeds the concrete design strength.

11.0 Do not exceed the under-run in length of a section by more than 1/2 inch.

The City will make no additional payment for changes to the project resulting from the manufacturer's dimensional changes in the structure.

Provide sections free of fractures spalls and chips with smooth and regular surfaces, defined as a 1/4 inch variation within 4 feet.

11.1 Do not vary the internal dimensions by more than the lesser of 1 percent from the design dimensions or 1 1/2 inches. Do not vary the haunch dimensions by more than 3/4 inch from the design dimension.

11.4 Ensure a maximum variation in the position of the reinforcement of 3/8 inch. Provide no less than 2 inches of cover over the reinforcement for the external surface of the top slab. The above tolerances or cover requirements do not apply to mating surfaces at the joint.

11.5 Resubmit any change in reinforcement from the shop drawings for approval.

12.0 Make repairs according to the City's requirements. The City will not make additional payments for culvert repairs. The City will accept sound, properly finished, and cured repairs.

13.0 Perform inspection at the project site.

Furnish precast concrete components from suppliers certified according to City Supplement 1073.

14.0 Form seams and slight surface irregularities that are expected from a wood panel forming system will not be cause for rejection. In addition, hairline cracks less than 0.01 inch will not be cause for rejection.

15.1 Locate the product marking on the interior of the arch section 1 foot below the leg haunch.

Add the product marking upon removal of the forms.

The City may require repetitive product markings before Final Acceptance of the Project.

706.053 Precast Reinforced Concrete Round Sections. Provide precast reinforced concrete elliptical and circular arch sections according to ASTM C 1504, with the following modifications:

This item consists of manufacturing precast reinforced concrete elliptical and circular arch sections for culverts.

Use precast concrete member manufacturers certified according to City Supplement 1073.

Ensure the manufacturer submits design calculations, a structural load rating and shop drawings according to 501.04 (A). Do not produce any units until approved drawings have been submitted to the City. Ensure the shop drawings include the following:

1. Load rate the structure according to the requirements of section 900 of ODOT's Bridge Design Manual.
2. All material specifications.
3. Plan view.
4. Elevation views.
5. Headwall and wingwall attachment requirements.
6. Dimensions.
7. All maintenance of traffic phases.
8. Section sizes.
9. Design handling strength.

The City will allow the Contractor to modify an approved shop drawing and resubmit according to 501.04 (A).

Ensure that the shop drawings also include the following special information as required:

1. For top mounted guardrail, show the guardrail plate and bolt locations in the plan view with holes a minimum of 6 inches from a joint.
2. The corrosion inhibitor used, if any, and dosage rate. The Laboratory will approve the dosage rate.

6.2.1 In addition, provide cement according to Item 701, except 701.07.

6.2.2 Provide fly ash conforming to 701.13.

6.2.4.9 Provide carbonate micro-fines according to 701.14 and Table 499.03-2.

6.3 Provide aggregates conforming to the quality requirements of 703.02.

6.4 Use chemical admixtures conforming to 705.12. Use a corrosion inhibitor unless using epoxy coated reinforcing steel. See the approved list of corrosion inhibiting admixtures on file at the Laboratory. Ensure that the manufacturers recognize the effect of corrosion inhibitors and admixtures on strength, entrained air content, workability, etc. of their concrete mixes. The manufacturer's choice of one of these corrosion inhibitors does not alleviate meeting all design requirements of this structure.

6.4.1 Provide air-entraining admixture conforming to 705.10.

6.5 Provide epoxy coated reinforcement according to 709.00, Grade 60 (Grade 420), or 709.14. In lieu of epoxy coated reinforcement, the Contractor may add an approved corrosion inhibiting admixture to the concrete at the approved dosage. Provide reinforcement according to 709.01, 709.03, or 709.05; Grade 60 (Grade 420) or 709.08, 709.10, 709.11 or 709.12. Provide epoxy or galvanized coated connections when connecting a precast structural unit into a cast-in-place structural component or between segments of adjacent precast structural units either manufactured as separate units or across construction joints when manufactured as one unit. Provide epoxy coated reinforcement according to 709.00 or 709.14, when designing these connections using reinforcing steel. Provide galvanized coatings according to 711.02, when designing these connections using connection plates, hardware or concrete inserts.

7.1 Modify the first sentence as follows: Design according to *AASHTO LRFD Bridge Design Specifications*, Section 12.14. Include a future wearing surface loading of 60 psf.

7.2 Ensure a minimum of 2 inches of concrete cover dimension over the outside circumferential reinforcement. Ensure a minimum of 1 1/2 inches concrete cover dimension over the inside circumferential reinforcement. Ensure a clear distance of the end circumferential wires no less than 1 inch or more than 2 inches from the ends of the sections. Assemble reinforcement utilizing single or multiple layers of welded wire fabric (three-layer maximum), or utilizing a single layer of deformed billet-steel bars. Use welded wire fabric composed of circumferential and longitudinal wires containing sufficient longitudinal wires extending through the section to maintain the shape and position of reinforcement. The City will accept longitudinal distribution reinforcement of welded wire fabric or deformed billet-steel bars. Ensure that the ends of the longitudinal distribution reinforcement extend no more than 3 inches from the ends of the sections.

Form the outside and inside circumferential reinforcing steel for the arch approximately equal to the configuration of the arch shape.

7.3 In addition, do not make tension splices in the circumferential reinforcement. For splices other than tension splices, the overlap a minimum of 12 inches for welded wire fabric or deformed billet steel bars. Space circumferential wires in a wire fabric sheet no less than 2 inches or more than 4 inches center-to-center. For the wire fabric, space the longitudinal wire no more than 8 inches center-to-center. Space the longitudinal distribution steel for either line of reinforcing in the top slab no more than 16 inches center-to-center.

8.1 Construct the sections with butt ends. Ensure that the ends of the sections, when laid together, make a continuous line of sections with a smooth interior free of appreciable irregularities, all compatible with the permissible variations in these Specifications and section 11 of ASTM C 1504. Provide a 3/4 × 3/4 inch minimum chamfer on the inside and outside surface at the sections joint.

Ensure a structurally continuous arch design throughout the arch unit providing for flexural, compressive and shear force transfers in its final constructed location. For arches that gain structural continuity by a cast in place closure at the project site, provide concrete with the same compressive strength as the precast arch. In addition, ensure that the cast in place closure provides continuity in the transverse direction (90 degrees to the span) along the lay length of the arches.

9.1 Ensure that the aggregate, cement, and water are manufactured according to 499.06, and 499.07.

Ensure that the temperature requirements of 511.08 and 511.15 are met.

Ensure that the proportion of cementitious and carbonate micro-fines material is not less than 564 pounds per cubic yard of concrete.

If used, add the corrosion inhibitor as an aqueous solution. Consider the water in the solution as mixing water for the purpose of determining the water-cement ratio of concrete.

9.2 Cure the arch sections in the forms for the length of time required to obtain the specified minimum design handling strength as defined in the shop drawings. Test a cylinder to check each section's design handling strength. Repeat this test as often as needed. The City will consider only one cylinder passing as proof of meeting the design handling strength. If the shop drawing shows no design handling strengths, then assume a minimum handling strength of 100 percent of the design strength. Ensure that the curing then continues either in or out of the forms until the concrete meets the specified minimum design strength.

9.2.1 The City will accept steam curing by low pressure steam or radiant heat within a suitable insulated enclosure to contain the live steam or heat as an accelerated cure method. Make the initial application of the steam or heat from 2 to 4 hours after the final placement of concrete to allow the initial set to take place. If using retarders, increase the waiting period to 4 to 6 hours. As an alternative, determine the actual time of initial set according to ASTM C 403. Do not start curing until the actual time to initial set elapses.

During the waiting period, ensure a temperature within the curing enclosure no less than 50 °F.

During the initial application of live steam or radiant heat, ensure that the ambient temperature within the curing enclosure increases at an average rate not exceeding 40 °F per hour until reaching the curing temperature.

Ensure that the maximum curing temperature does not exceed 150 °F. Hold the design temperature until the concrete reaches the desired design strength. Do not direct the application of live steam on the concrete forms so as to cause localized high temperatures.

9.2.2 Provide water curing according to 511.15 and 511.17, Method A.

9.3 Keep all forms place until meeting the design handling strength.

Do not make holes for handling or setting. Do not move members before the design handling strength of the concrete is reached, or shipped before the design strength of the concrete is reached. Ensure that the manufacturers possess equipment necessary to handle and transport the pieces without damaging them.10 Ensure that the hardened concrete contains a minimum of 4 percent entrained air.

10.1 Do not drill cores from the section.

10.2.1 Keep the cylinders and matching arch section together to guarantee that the cylinders match the corresponding culvert section; or, upon agreement by the City, keep the cylinders at a location that provides the same environment as the arch sections.

10.2.2 For each section of the arch structure, produce at least four cylinders with markings that identify the cylinders with the matching arch section.

10.2.3 Conform to City Supplement 1073 for acceptance.

10.2.3.1 Ensure that cylinder strengths conform to City Supplement 1073.

11.0 Do not under-run the length of a section by more than 1/2 inch.

The City will make no additional payment for changes to the project resulting from the Contractor's dimensional changes in the structure.

Provide sections free of fractures spalls and chips with smooth surfaces and regular finish defined as a 1/4 inch variation within 4 feet.

11.1 Do not vary the internal dimensions by any more than the lesser of 1 percent from the design dimensions or 1 1/2 inches. Do not vary the haunch dimensions by more than 3/4 inch from the design dimension.

11.4 Ensure a maximum variation in the position of the reinforcement of 3/8 inch. Provide no less than 2 inches of cover over the reinforcement for the external surface of the top. The above tolerances or cover requirements do not apply to mating surfaces at the joint.

11.5 Resubmit any change in reinforcement from the shop drawings for approval.

11.6 Provide a smooth steel form finish for all interior and exterior arch surfaces.

12.0 Make repairs according to the City's requirements. The City will not make additional payments for arch repairs. The City will accept sound, properly finished, and cured repairs.

13.0 The City may inspect the plant according to City Supplement 1073 and will perform final inspection and acceptance at the project site.

Furnish precast concrete components from suppliers certified according to City Supplement 1073.

14.0 Form seams and slight surface irregularities that are expected from a steel panel forming system will not be cause for rejection. In addition, hairline cracks less than 0.01 inch will not be cause for rejection.

15.1 Locate the product marking on the interior of the arch section 4 feet above the base of the arch. Measure the 4 feet from the base of the arch along the circumference of the interior surface.

Add the product marking upon removal of the forms.

The manufacturer may be required to repeat the product markings before the project is final.

706.06 Perforated Concrete Pipe. Provide perforated concrete pipe according to ASTM C 444, and 706.01 or 706.02.

Use materials from manufacturers certified by the City.

706.07 Concrete Drain Tile. Provide extra-quality concrete drain tile according to ASTM C 412, with the following modifications:

Use materials from manufacturers certified by the City.

4.0 This specification covers extra-quality concrete drain tile only.

5.1(3) Does not apply.

6.2.1 Provide cement according to Item 701, except 701.07.

6.2.2 Provide fly ash according to 701.13.

6.3 Provide aggregate conforming to the quality requirements of 703.02.

8.1 Perform inspection at the project site. Obtain random samples from material delivered to the project site or at other locations designated by the Laboratory. Use materials from manufacturers certified by the City.

Testing. Ensure that the manufacturer furnishes all facilities and personnel to carry out the tests.

706.08 Vitrified Clay Pipe. Provide vitrified clay pipe according to ASTM C 700, with the following modifications:

Furnish materials according to the City's Consignment List.

14.0 Perform all tests except hydrostatic according to ASTM C 301.

15.0 Perform inspection at the project site. Obtain random samples from material delivered to the project site or at other locations designated by the Laboratory.

706.09 Clay Drain Tile. Provide extra-quality clay drain tile according to ASTM C 4, with the following modifications:

6.1 Perform inspection at the project site. Obtain random samples from material delivered to the project site or at other locations designated by the Laboratory.

11, 12, and 13 Ensure that the manufacturer furnishes all facilities and personnel to carry out the tests.

Furnish materials according to the City's Consignment List.

706.10 Bituminous Pipe Joint Filler. Provide cold applied, mineral filled, joint sealing compound for joints of bell and spigot, or tongue and groove sewer; or drain pipe conforming to the following:

A. Composition. Provide a steam-refined petroleum asphalt or a refined coal tar, dissolved in a suitable solvent, and containing an appropriate stiffener.

B. General Requirement. Provide a bituminous plastic cement that has a smooth, uniform mixture, not thickened or livered, and that shows a separation easily overcome by stirring. Provide material of such consistency and properties that allows application with a trowel, a putty knife, or with a caulking gun without pulling or drawing. Provide a material that when applied to metal, concrete, or vitrified clay surfaces, exhibits good adhesive and cohesive properties and has only slight shrinkage after curing. Provide material undamaged by exposure to below freezing temperatures.

C. Detail Requirements. Provide materials conforming to the following requirements:

1.	When applied in a layer 1/16 to 1/8-inch thick on a tinned metal panel and cured at room temperature for 24 hours, the bituminous plastic cement shall set to a tough, plastic coating, free from blisters.		
		Minimum	**Maximum**
2.	Grease Cone Penetration (unworked, 150 grams, 25 °C, 5 sec, ASTM D 217, mm/10	175	250
3.	Weight, kg/L	1.17	--
4.	Non-volatile, 10 g, 105 to 110 °C, 24 hrs, %	75	--
5.	Ash, by ignition, %	25	45

706.11 Resilient and Flexible Gasket Joints. Provide resilient and flexible gasket joints for concrete pipe according to ASTM C 443.

706.12 Resilient and Flexible Joints. Provide resilient and flexible joints for vitrified clay pipe according to ASTM C 425.

706.13 Precast Reinforced Concrete Manhole Riser Sections, Flat Slab Tops, Catch Basins and Inlet Tops, and Portable Barriers. All manhole and barrier structures will conform to ASTM C478. All catch basins, inlets, and inlet tops will conform to ASTM C913.

Perform compression tests for satisfying the minimum specified concrete strength requirements from cores not less than 3 1/2 inches (90 mm) in diameter drilled from the wall of the risers, cones, tops, or barriers. Obtain cores prepared for testing, and tested by the appropriate methods of ASTM C 497 (ASTM C 497 M). In addition, ensure that all concrete compression tests made on cores are drilled from precast sections. Provide precast catch basins, inlet tops, and temporary barriers that have 6 ± 2 percent air in the hardened concrete.

Absorption tests do not apply.

Wet Cast Items will require 6 ± 2% entrained air as tested per ASTM C138.

Dry Cast Items do not require entrained air.

706.14 Preformed Flexible Joint Sealant. Provide preformed flexible joint sealant for concrete conduit according to ASTM C 990.

706.15 Precast Reinforced Concrete Outlets. Provide precast reinforced concrete outlets composed of cement conforming to Item 701, except 701.07. Provide aggregate conforming to the quality requirements of 703.02. Provide epoxy coated steel reinforcement conforming to 709.00. Do not provide holes for handling or laying. Provide concrete outlets with the outlet hole the same size as the outlet pipe. Perform inspection at the project site.

Use manufacturers certified according to City Supplement 1073.

706.16 Resilient Connectors between Precast Manhole Riser Sections, Catch Basins, Inlets, and Pipes. Material and performance requirements shall meet the standards of ASTM C923, and be approved by the Engineer. The actual joint may be one of the following designs:

(a) Rubber sleeve with stainless steel band

(b) Rubber gasket compression

(c) Rubber gasket expansion

ITEM 707 STEEL AND ALUMINUM PIPE

707.00 Acceptance.
707.01 Metallic Coated Corrugated Steel Conduits and Underdrains.
707.02 Metallic Coated Corrugated Steel Conduits [1-inch Corrugations].
707.03 Structural Plate Corrugated Steel Structures.
707.04 Precoated, Galvanized Steel Culverts.
707.05 Bituminous Coated Corrugated Steel Pipe and Pipe Arches with Paved Invert [1/2-inch Corrugations].
707.07 Bituminous Coated Corrugated Steel Pipe and Pipe Arches with Paved Invert [1-inch Corrugations].
707.10 Square and Rectangular Steel Tubing.
707.13 Bituminous Lined Corrugated Steel Pipe [1/2-inch Corrugations].
707.14 Bituminous Lined Corrugated Steel Pipe [1-inch Corrugations].
707.21 Corrugated Aluminum Alloy Conduits and Underdrains.
707.22 Corrugated Aluminum Alloy Conduits.
707.23 Aluminum Alloy Structural Plate Conduits.
707.70 Welded and Seamless Steel Pipe.

707.00 Acceptance. Corrugated metal pipe conforming to 707.01, 707.02, 707.03, 707.04, 707.05, 707.07, 707.13, 707.14, 707.21, 707.22, and 707.23 may be accepted for shipment to and immediate use in construction projects when provided from suppliers certified by the City.

707.01 Metallic Coated Corrugated Steel Conduits and Underdrains. Provide conduits and underdrains with a corrugation depth of 1/2 or 1/4 inch and according to AASHTO M 36/M 36M, with the following modifications:

7.5 Either helical lock or continuous welded seams.

7.7.1 At least two annular corrugations at each end of each helical corrugated pipe, 12-inch diameter and larger pipe length.

8.1.2 Provide steel pipe and pipe-arches with the following minimum wall thicknesses (coated):

Pipe		Pipe Arch	
Diameter (in)	Wall Thickness (in)	Size (in)	Wall Thickness (in)
6	0.048		
8	0.060		
10	0.060		
12	0.060		
15	0.060	17 × 13	0.060
18	0.060	21 × 15	0.060
21	0.060	24 × 18	0.060
24	0.060	28 × 20	0.075
27	0.075		
30	0.075	35 × 24	0.075
36	0.075	42 × 29	0.105
42	0.105	49 × 33	0.105
48	0.105	57 × 38	0.135
54	0.105	64 × 43	0.135
60	0.135	71 × 47	0.164
66	0.164		
72	0.164		

Ensure that the minus tolerance conforms to AASHTO M 218, M 274, or M 289.

TABLE 707.01-1 PIPE REQUIREMENTS

Nominal Inside Diameter (inch)	Corrugation Depth Nominal (inch)	Minimum Width of Lap (inch)
27	1/2	2
33	1/2	2

8.3.2.1 Ensure a minimum number of four longitudinal rows of perforations.

9.1 Coupling bands with annular corrugations.

9.2 Use coupling bands not more than two nominal sheet thicknesses thinner than the thickness of the connection pipe. For pipes 48-inch diameter and smaller, use a coupling band no thinner than the 0.052-inch nominal sheet thickness. For pipes 54-inch diameter through 84-inch

diameter, use a coupling band no thinner than the 0.064-inch nominal sheet thickness. For pipe diameters over 36 inches, provide coupling bands with at least one annular corrugation that indexes into the inboard corrugation of each pipe section joined.

707.02 Metallic Coated Corrugated Steel Conduits [1-inch Corrugations]. Provide conduits according to AASHTO M 36/M 36M, with the following modifications:

7.5 Helical lock or continuous welded seams.

7.7.1 At least two annual corrugations at each end of each helical corrugated pipe length.

8.1.2 Minimum wall thickness (coated) of steel pipe and pipe-arches as follows:

Pipe	
Diameter (inch)	**Wall Thickness (inch)**
36	0.064
42	0.064
48	0.064
54	0.079
60	0.079
66	0.109
72	0.109
78	0.109
84	0.109
90	0.109
96	0.109
102	0.109
108	0.109
114	0.109
120	0.109

Pipe Arch	
Size (inch)	**Wall Thickness (inch)**
40 × 31	0.109
46 × 36	0.109
53 × 41	0.109
60 × 46	0.109
66 × 51	0.109
73 × 55	0.109
81 × 59	0.109
87 × 63	0.109
95 × 67	0.109
103 × 71	0.109
112 × 75	0.109
117 × 79	0.109
128 × 83	0.138
137 × 87	0.138
142 × 91	0.168

Ensure that the minus tolerance conforms to AASHTO M 218, M 274, or M 289.

9.1 Provide coupling bands with a minimum wall thickness (coated) of 0.064 inch and with at least one annular corrugation that indexes into the inboard corrugations of each pipe section joined.

707.03 Structural Plate Corrugated Steel Structures. Provide structural plate pipe, pipe arch, and arch structures according to AASHTO M 167, with the following modification:

5.4 Assembly bolts galvanized by an electrolytic process.

707.04 Precoated, Galvanized Steel Culverts. Provide conduits and coupling bands according to AASHTO M 245/M 245M, as modified by 707.01 and 707.02. Ensure that the precoated, galvanized steel sheets conform to AASHTO M 246/M 246M, Type B. Provide a polymeric coating of 10 mils on the interior and 10 mils on the exterior.

707.05 Bituminous Coated Corrugated Steel Pipe and Pipe Arches with Paved Invert [1/2-inch Corrugations]. Provide conduits and coupling bands according to 707.01 and to AASHTO M 190. Provide either Type B half bituminous coated pipe, or pipe arches with paved invert or Type C fully coated pipe, or pipe arches with paved invert.

707.07 Bituminous Coated Corrugated Steel Pipe and Pipe Arches with Paved Invert [1-inch Corrugations]. Provide conduits and coupling bands according to 707.02 and to AASHTO M 190. Provide either Type B half bituminous coated pipe, or pipe arches with paved invert or Type C fully coated pipe, or pipe arches with paved invert.

707.10 Square and Rectangular Steel Tubing. Provide square and rectangular steel tubing according to ASTM A 501 or ASTM A 500, Grade B, with the following modifications:

Galvanize the tubing according to 711.02.

Test the tubular steel from all heat numbers supplied for toughness according to ASTM E 436, except as modified herein. Take and test tubing test samples before delivery of the railing. Witness the taking of the test samples and use an independent test laboratory for testing. Submit certified test data for review and approval as specified in 501.06.

Perform testing on test specimens obtained from galvanized tubing with the same heat number as the tubing the Contractor plans to use. Conduct the testing at a temperature of 0 °F on 2 × 9-inch specimens supported to provide a 7-inch clear span. Do not remove the galvanizing from the specimens. Cut three 2 × 9-inch test specimens from each of the unwelded sides for a total of nine specimens. If all three unwelded sides do not provide a large enough area to remove 2 × 9-inch specimens, then remove nine specimens from any unwelded side.

Disregard the three specimens from the side with the lowest average shear area when calculating the final average shear area. For specimens not removed from three unwelded sides, disregard the three specimens with the lowest average shear area. Calculate the final average shear area using the six remaining specimens. If the average shear area falls below 50 percent, reject material from the heat represented by these tests.

However, for an average shear area of 30 percent or greater, the City will allow one retest at a sampling frequency three times that of the first test, and with no samples excluded in calculating the average. Reject materials with less than a 50 percent average shear area upon retest.

Before galvanizing, ensure that the manufacturer of the tubing identifies the product with the steel heat number (or with some number traceable to the heat number) and with the manufacturer's unique identification code to facilitate acceptance or rejection of the material. Place the identification on only one face of the section and repeat at intervals no greater than 4 feet. Do not extend the identification into the curved surface of the tubing at the corners.

707.13 Bituminous Lined Corrugated Steel Pipe [1/2-inch Corrugations]. Provide pipe according to 707.01 and AASHTO M 190, Type D.

707.14 Bituminous Lined Corrugated Steel Pipe [1-inch Corrugations]. Provide pipe according to 707.02 and AASHTO M 190, Type D.

707.21 Corrugated Aluminum Alloy Conduits and Underdrains. Provide conduits and underdrains with a 1/4, 7/16, or 1/2-inch corrugation depth and according to AASHTO M 196/M 196M, with the following modifications:

8.1 and 8.2 Provide helically corrugated pipe 12 inches in diameter and larger with at least two circumferential corrugations at each end of each pipe length.

8.1.2 Provide Corrugated Aluminum Alloy Conduits and Underdrains with minimum wall thicknesses as follows:

Pipe		Pipe Arch	
Diameter (inch)	**Wall Thickness (inch)**	**Size (inch)**	**Wall Thickness (inch)**
6	0.048		
8	0.060		
10	0.060		
12	0.060		
15	0.060	17 × 13	0.060
18	0.060	21 × 15	0.060
21	0.060	24 × 18	0.060
24	0.060	28 × 20	0.075
27	0.075		
30	0.075	35 × 24	0.075
36	0.075	42 × 29	0.105
42	0.105	49 × 33	0.105
48	0.105	57 × 38	0.135
54	0.105	64 × 43	0.135
60	0.135	71 × 47	0.164
66	0.164		
72	0.164		

Ensure that the minus tolerance conforms to AASHTO M 197/M 197M.

9.2 Provide coupling bands with a minimum wall thickness (coated) of 0.060 inch. For pipe diameters 12 inches and larger, provide coupling bands with at least one circumferential corrugation that indexes into the inboard corrugations of each pipe section joined.

707.22 Corrugated Aluminum Alloy Conduits. Provide conduits with a 1-inch corrugation depth and according to AASHTO M 196/M 196M, with the following modifications:

8.1 and 8.2 Provide helically corrugated pipe with at least two circumferential corrugations at each end of each pipe length.

8.1.2 Provide Corrugated Aluminum Alloy Conduits with minimum wall thicknesses as follows:

Pipe	
Diameter (inch)	**Wall Thickness (inch)**
36	0.060
42	0.060
48	0.060
54	0.075
60	0.105
66	0.105
72	0.105
78	0.105
84	0.105
90	0.105
96	0.105
102	0.135
108	0.135
114	0.164
120	0.164

Ensure that the minus tolerance conforms to AASHTO M 197/M 197M.

9.2 Provide coupling bands no lighter than 0.060-inch nominal sheet thickness and with at least one circumferential corrugation that indexes into the inboard corrugations of each pipe section joined.

707.23 Aluminum Alloy Structural Plate Conduits. Provide aluminum alloy plates and fasteners for structural plate conduits according to AASHTO M 219/M 219M.

707.70 Welded and Seamless Steel Pipe. Provide welded and seamless steel pipe according to ASTM A 53 or ASTM A 139/A 139M, Grade B, with the following modifications:

20.1 Perform inspection at the project site. Obtain random samples from material delivered to the project site or at other locations designated by the Laboratory.

Furnish materials according to the City's Approved Producers / Qualified Products List.

ITEM 708 PAINT

708.01 Inorganic Zinc Silicate Primer Paint.
708.02 OZEU Structural Steel Paint.

708.01 Inorganic Zinc Silicate Primer Paint. Provide inorganic zinc silicate primer paint conforming to AASHTO M 300, Type I, and the following modification:

5.1 A green colorant approximately No. 34159 of FS 595C.

Follow the submittal requirements of ODOT Supplement 1084 to obtain approval of materials conforming to this specification.

Submit new certified test results if the formulation or manufacturing process changes, or as requested by the City.

Furnish materials certified according to ODOT Supplement 1084 and listed on the City's QPL.

708.02 OZEU Structural Steel Paint. This specification covers the formulation and testing of a three-coat structural steel paint system consisting of an organic zinc prime coat, an epoxy intermediate coat, and a urethane finish coat (OZEU). Meet the following material requirements for the respective coats:

A. General. For each lot of all coatings, furnish a coated card (Drawdown card) that shows the color, gloss, and general appearance of the material covered by the lot. Use a minimum card size of 3-inches by 5-inches. Ensure that the color matches the color card furnished for the Contract or order within visual limits determined by the Engineer. In case of disagreement, provide test data according to ASTM D 2244 showing a color difference of no greater than 2.0, ΔE^* (CIE 1976 L*a*b*).

B. Organic Zinc Prime Coat. Provide an organic zinc prime coat consisting of a zinc dust filled, two or three-component epoxy polyamide, and selected additives as required. Ensure that the coating meets the following:

1. Physical Requirements.

Total solids, % by weight of paint,	ASTM D 2369	70 percent minimum
Pigment, % by weight of total solids,	ASTM D 2371	83 percent minimum
Total zinc dust, % by weight of pigment	ASTM D 521	93 percent minimum
Total zinc, % by weight of total solids (by calculation)	ASTM D 521	77 percent minimum
Total solids, % by volume,	ASTM D 2697	45 percent minimum
Color Greenish gray	approximating FS-595C-34159	visual comparison
Pot life. SSPC-Paint 22, Section 5.5 with the following exception: 6 hours minimum at 77+/-3 °F		Follow the paint manufacturers recommendations for applying the coating within the pot life specified with no evidence of gelation. The coating will be in a free-flowing condition and easily sprayed.

2. Qualitative Requirements.

   a. Mixing. Section 6.1, SSPC-Paint 20 using only a high shear (Jiffy) mixer.

   b. Storage Life. Section 6.3, SSPC-Paint 20.

   c. Mudcracking. Section 7.1, SSPC-Paint 20.

3. Material Quality Assurance. Analysis for each component.

   Material Quality Assurance will conform to the requirements of ODOT Supplement 1084.

C. Epoxy Intermediate Coat. Provide a two-part epoxy intermediate coat composed of a base component and curing agent suitable for application over the zinc rich primer.

Use a base component that contains an epoxy resin together with color pigments, mineral fillers, gellant, leveling agent, and volatile solvents. Use a curing agent component contains a liquid polyamide resin and volatile solvent. Ensure that the coating meets the following:

1. Physical Requirements.

   a. Color. White, meeting or exceeding, FS-595C-37875 according to ASTM E 1347.

   b. Components. Two, mixed before application.

   c. Volume solids, ASTM D 2697. 50 percent minimum.

   d. Pot life. SSPC-Paint 22, Section 5.5 with the following exception: 6 hours minimum at 77+/-3 °F with no evidence of gellation. Free-flowing and easily sprayed

   e. Curing time.

Set-to-touch	ASTM D 1640	4 hours, maximum at 77 °F
Dry-to-recoat	ASTM D 1640	24 hours, maximum at 77 °F

   No pick-up when rubbed with a cloth soaked in Methyl Ethyl Ketone.

   f. Fineness of grind, ASTM D 1210. Hegman 3 minimum.

   g. Volatile Organic Compounds (VOC), maximum, ASTM D 3960. 2.83 lb/gal, as applied.

2. Material Quality Assurance. Material Quality Assurance conforming to the requirements of ODOT Supplement 1084.

D. Urethane Finish Coat. Provide a two-component urethane finish coat composed of a polyester and/or acrylic aliphatic urethane and suitable for use as a finish coat over the white epoxy polyamide intermediate coat. Ensure that the coating meets the following:

1. Physical Requirements.

   a. Finish, Specular gloss, ASTM D 523. Use Fed. Std. 595C-16440 Gray: 70 % minimum after 3000 hours weathering resistance. Color change less than 2.0 ΔE*, (C.I.E 1976 L*a*b*) ASTM D2244.

   b. Volume solids, ASTM D 2697. 42 percent minimum.

   c. Curing time, at 77 °F and 50% RH. Set-to-touch, ASTM D 1640: 30 minutes, minimum; 4 hours, maximum.

d. Pot life. Follow the paint manufacturers recommendations for applying the coating within the pot life specified with no evidence of gelation. The coating will be in a free-flowing condition and easily sprayed.

e. Volatile Organic Compounds (VOC), maximum, ASTM D 3960. 2.83 lb/gal, as applied.

f. Colors.

(1) Specified.[2]

Brown	FS-595C, 10324
Green	FS-595C, 14277
Blue	FS-595C, 15526
[2] Contractor's choice unless specified on plans	

(2) Elective. As specified on the plans.

g. Gloss requirements, ASTM D 523.

Full gloss	minimum 80% unless specified on the plans
Semi-gloss	30 to 45%
Lusterless (Matte)	maximum 6%

2. Material Quality Assurance. Material Quality Assurance conforming to the requirements of ODOT Supplement 1084.

Performance Requirements. Prior to use, test the coating system consisting of the organic zinc prime coat, the epoxy intermediate coat, and the urethane topcoat.

Prepare three panels for each of the specified tests according to ASTM D 609, except provide a minimum thickness of 1/8 inch and use ASTM A 36/A 36M hot rolled steel. Blast clean (using coal slag abrasive) the surface to equal, as nearly as is practical, the standard Sa 2 1/2 of ASTM D 2200 (Steel Structures Painting Council SSPC-SP10 meets this requirement). Ensure that the surface has a nominal height of profile of 1 to 3.5 mils verified by using appropriate replica tape. Coat and cure the panels according to the manufacturer's printed instructions. Provide a dry film coating thickness for the system to be tested as follows:

Organic Zinc:	3.0 to 5.0 mils
Epoxy:	5.0 to 7.0 mils
Urethane:	2.0 to 4.0 mils

Ensure that the coating system passes each of the following tests:

A. Fresh Water Resistance Test (ASTM D 870). Scribe the panels according to ASTM D 1654 to the depth of the base metal in the form of an "X" having at least 2-inch legs, and immerse panels in fresh tap water at 75 ± 5 °F. After 30 days of immersion, examine the panels to verify that they show no rusting and that the coating shows no blistering, softening, or discoloration. Rate blistering according to ASTM D 714.

B. Salt Water Resistance Test (ASTM D 870). Scribe the panels as specified in "A" above, and immersed panels in a water solution of 5 percent sodium chloride at 75 ± 5 °F. After 7, 14, and 30 days of immersion, examine the panels to verify that they show no rusting and that the coating shows no blistering or softening. Rate blistering according to ASTM D 714. Replace the sodium chloride solution with a fresh solution after examination at 7 and 14 days.

C. Weathering Resistance Test. Test the panels according ASTM D 4587, Method D, using Ultra Violet A 340 bulbs. Place the panels on test at the beginning of a wet cycle. After 3000 hours of continuous exposure, examine the panels to verify that they show no rusting and that the coating shows no blistering or loss of adhesion. Perform the 60 degree specular gloss measurements on the sprayed panels utilized for this test. Average the three initial measurements (one per panel) together. Also, average the three final measurements together.

D. Salt Fog Resistance Test. Scribe the panels as specified in "A" above, and test them according to ASTM B 117. After 3000 hours of continuous exposure, examine the coating to verify that it shows no loss of bond and that it shows no rusting or blistering beyond 1/16 inch from the center of the scribe mark. Rate blistering according to ASTM D 714.

E. Adhesion Test, ASTM D 4541 Type IV. Test the panels according to the following:

1. Lightly sand the coating surface and aluminum dolly, and apply a quick set adhesive.
2. Allow adhesive to cure overnight.
3. Scribe the coating and adhesive around the dolly before testing.
4. Make a minimum of 4 trials to failure, and report the 4 trials. Ensure that each trial is greater than 400 pounds per square inch. Reject trial if fracture at the primer-blast interface occurs.

F. Pencil Hardness Test, **ASTM D 3363**. Determine the hardness of an individual coat or the coating system by performing a Pencil Hardness Test according to ASTM D 3363. Meet or exceed scale of hardness HB for the coating.

Prequalification. Before approval, submit copies of the manufacturer's certified test data to the Laboratory showing that the coating system complies with the performance requirements of this specification. Provide certified test data that states the following physical properties for each coating: Density, pounds per gallon; Solids, percent by weight; Solids, percent by volume; Viscosity; Drying time; and VOC content, pounds per gallon.

Use an independent testing laboratory, approved by the Laboratory, to develop the test data. Include with the test data the brand name of the paint, name of manufacturer, number of lots tested, and date of manufacture.

Once the Engineer approves the coating, the City will not require further performance testing by the manufacturer unless the formulation or manufacturing process changes, in which case the City will require new certified test results.

Sampling. The Laboratory will establish acceptance variances.

Furnish materials certified according to ODOT Supplement 1084 and listed on the City's QPL.

ITEM 709 REINFORCING STEEL

709.00 Epoxy Coated Reinforcing Steel.
709.01 Deformed and Plain Billet Steel Bars for Concrete Reinforcement.
709.03 Rail Steel Deformed and Plain Bars for Concrete Reinforcement.
709.05 Axle Steel Deformed and Plain Bars for Concrete Reinforcement.
709.07 Electric-Resistance-Welded Carbon and Alloy Steel Mechanical Tubing.
709.08 Cold-Drawn Steel Wire for Concrete Reinforcement.
709.09 Fabricated Steel Bar or Rod Mats for Concrete Reinforcement.
709.10 Welded Steel Wire Fabric For Concrete Reinforcement.
709.11 Deformed Steel Wire for Concrete Reinforcement.
709.12 Welded Deformed Steel Wire Fabric for Concrete Reinforcement.
709.13 Coated Dowel Bars.
709.14 Epoxy-Coated Steel Wire and Welded Wire Fabric for Reinforcement.
709.15 Plastic Supports for Reinforcing Steel.
709.16 Galvanized Reinforcing Steel Option for Bridge Structure Spirals.
709.17 General.

709.00 Epoxy Coated Reinforcing Steel. Provide epoxy coated reinforcing steel according to ASTM A 775/A 775M, with the following modifications:

5.1 Provide steel reinforcing bars free of excessive rust, oil, grease, and paint that conform to 709.01, 709.03, or 709.05.

5.2 Use a coating material that meets the requirements listed in Annex A1and is colored to facilitate inspection of the installed bar. The City will approve the color.

5.3 Sample required.

8.3.1 Evaluate the adhesion of the coating by bending production coated bars around a mandrel of specified size according to the bending tables in ASTM A 615 or ASTM A 996 as applicable. Perform the bend test for adhesion of the coating at a uniform rate, and ensure that it takes up to 90 seconds to complete. Place the two longitudinal deformations in a plane perpendicular to the mandrel radius. Ensure a thermal equilibrium between 68 and 86 °F for the test specimens.

12.1 Perform tests, inspection, and sampling at a site specified by the Engineer. Sampling for testing requires three 30-inch samples for each bar size, for each coating lot, and for each heat of steel reinforcing bars.

14.1 Report of test results required.

Where fabricating reinforcing bar cages for prestressed concrete beams by tack welding, patch the areas damaged by the tack welding according to ASTM A 775, Section 11, Permissible Amount of Damaged Coating and Repair of Damaged Coating.

709.01 Deformed and Plain Billet Steel Bars for Concrete Reinforcement. Provide deformed and plain billet steel bars for concrete reinforcement according to ASTM A 615, with the following modification:

13.1 Where the Contractor can make positive identification of a heat, perform one tension test and one bend test from each bar designation number of each heat in the Lot. Where the Contractor cannot practically identify the heat, perform one tension test and one bend test for each bar designation number in each lot of 10 tons or fraction thereof.

Furnish certified material according to ODOT Supplement 1068.

709.03 Rail Steel Deformed and Plain Bars for Concrete Reinforcement. Provide rail steel deformed and plain bars for concrete reinforcement according to ASTM A 996.

Furnish certified material according to ODOT Supplement 1068.

709.05 Axle Steel Deformed and Plain Bars for Concrete Reinforcement. Provide axle steel deformed and plain bars for concrete reinforcement according to ASTM A 996.

Furnish certified material according to ODOT Supplement 1068.

709.07 Electric-Resistance-Welded Carbon and Alloy Steel Mechanical Tubing. Provide grade 60 carbon steel round tubing with a minimum 60 ksi yield strength according to ASTM A 513, with the following modifications:

14.1 Galvanize both the interior and exterior of the tubing with a minimum thickness of 0.30oz/ft^2 zinc. If welded tubing is used, re-metallize the outside weld with zinc.

Furnish certified materials according to ODOT Supplement 1068.

709.08 Cold-Drawn Steel Wire for Concrete Reinforcement. Provide cold drawn steel wire for concrete reinforcement according to ASTM A 82 or ASTM A 1064, with the following modification:

7.2 Completely cover galvanized wire with a coating of pure zinc of uniform thickness, so applied that it adheres firmly to the surface of the wire. Ensure a minimum weight of zinc coating of 0.8 ounces per square foot of surface as determined by ASTM A 90.

Furnish certified material according to ODOT Supplement 1068.

709.09 Fabricated Steel Bar or Rod Mats for Concrete Reinforcement. Provide fabricated steel bar or rod mats for concrete reinforcement according to ASTM A 184, with the following modifications:

4 Use deformed bars.

4.1 Provide longitudinal bars conforming to Grade 60 of 709.01, 709.03, or 709.05.

4.2 Provide longitudinal bars according to 709.01, Grade 60. Provide transverse bars according to 709.01.

Furnish certified material according to ODOT Supplement 1068.

709.10 Welded Steel Wire Fabric For Concrete Reinforcement. Provide welded steel wire fabric for concrete reinforcement according to ASTM A 185 or ASTM A 1064.

Furnish certified material according to ODOT Supplement 1068.

709.11 Deformed Steel Wire for Concrete Reinforcement. Provide deformed steel wire for concrete reinforcement according to ASTM A 496 or ASTM A 1064.

Furnish certified material according to ODOT Supplement 1068.

709.12 Welded Deformed Steel Wire Fabric for Concrete Reinforcement. Provide welded deformed steel wire fabric for concrete reinforcement according to ASTM A 497 or ASTM A 1064.

Furnish certified material according to ODOT Supplement 1068.

709.13 Coated Dowel Bars. Provide coated dowel bars according to AASHTO M 254, with the following modifications:

4.1 Provide core material consisting of steel according to 709.01, 709.03, or 709.05.

Coat all surfaces of dowel bars. Suitably re-coat ends of dowel bars that have been cut to length after coating or have not had the uncoated ends coated during manufacturing or fabrication. Prepare surface and patch uncoated bar ends with material equivalent to the original epoxy coating.

If the Contractor elects to use basket supports for positioning of the above dowel bars as specified in 451.08.B or as shown on the plans, provide a fusion-bonded epoxy coated basket dowel bar assembly. Repair uncoated areas with surface preparation and patching material equivalent to the original epoxy coating.

Suitably repair coating on the dowel bars or baskets damaged during installation.

Do not expose coated dowels to weather or sunlight for a period exceeding 180 days.

Furnish certified material according to ODOT Supplement 1068.

709.14 Epoxy-Coated Steel Wire and Welded Wire Fabric for Reinforcement. Provide epoxy coated steel wire and welded wire fabric for reinforcement according to ASTM A 884, with the following modifications:

5.1 Use plain or deformed steel wire or welded wire fabric free of oil, grease, or paint and conforming to 709.08, 709.10, 709.11, or 709.12.

8.1 Ensure that the coating thickness conforms to Type A. Provide dry film thickness of 5 to 12 mils.

8.4 Test coated steel wire or welded wire fabric at the manufacturer's plant before shipment or at other sites as designated by the Laboratory.

Furnish certified material according to ODOT Supplement 1068.

709.15 Plastic Supports for Reinforcing Steel. Conform to ODOT Supplement 1125.

709.16 Galvanized Reinforcing Steel Option for Bridge Structure Spirals. As an option to 709.00 provide galvanized reinforcing steel for the spiral bars only in round column and drilled shaft reinforcing steel cages. Galvanized steel will conform to ASTM A767, Class 1. The galvanized coated reinforcing steel will meet all other requirements of Item 509.

Apply the galvanized coating after fabricating the reinforcing. If the galvanized surface becomes damaged during handling in the field, repairs will conform to ASTM A780.

When the City requests a sample, provide a replacement splice conforming to the lap length requirements for epoxy coated reinforcing.

Furnish certified material according to ODOT Supplement 1068.

709.17 General. All reinforcing steel furnished under this specification shall be free of excessive rust, grease, oil and paint.

ITEM 710 FENCE AND GUARDRAIL

710.01 Barbed Wire.
710.02 Woven Steel Wire Fence, Type 47.
710.03 Chain-Link Fence.
710.06 Deep Beam Rail.
710.09 Wire Rope Rail.
710.11 Fence Posts and Braces.
710.12 Square-Sawed and Round Guardrail Posts.
710.14 Pressure Treated Guardrail and Fence Posts, Braces, and Blocks.
710.15 Steel Guardrail Posts.
710.16 Guard Posts.

710.01 Barbed Wire. Provide barbed wire according to ASTM A 121, Type Z, Class 3 Galvanizing, or ASTM A 585, Type I, with the following modifications:

A. ASTM A 121, Type Z, Class 3.

6.3.1 Provide the weight of coating for various gages of wire composing the strands and barbs not less than 0.80 ounces per square foot of surface.

7.1 Provide No. 12 1/2, 13 1/2 or 15 1/2 steel wire gage barbed wire. Provide four point round steel wire barbs spaced 5 inches center-to-center.

9.1 Select one sample, according to Section 9.2, from each 50 spools or fraction thereof.

11.1 Perform inspection at the project site.

Provide certified material in accordance with ODOT Supplement 1067.

B. ASTM A 585, Type I.

12.3 Does not apply.

14.1 Perform inspection at the project site.

Provide certified material in accordance with ODOT Supplement 1067.

710.02 Woven Steel Wire Fence, Type 47. Provide woven steel wire fence in accordance with ASTM A 116, Type Z, Class 3 galvanizing, with the following modifications:

7.1 Design the fence fabric using design number 1047-6.9.

11.1 Perform inspection at the project site.

In addition, galvanize all hardware and attachments in accordance with Section 711.02.

Provide certified material in accordance with ODOT Supplement 1067.

710.03 Chain-Link Fence. Provide chain-link fence in accordance with AASHTO M 181, with the following modifications:

3.1 Provide posts, gate frames, and post braces, made of Type I or Type III material. Provide Type I material conforming to the requirements of Table 710.03-1. Provide Type III material conforming to the requirements of Table 710.03-2.

Fasten the fabric to the posts using either aluminum alloy or galvanized steel bands or wires. Provide wires that have a 0.148-inch minimum diameter and a zinc coating or steel fasteners that are not less than 0.8 ounces per square foot.

Provide stretcher bars having a 3/4 × 3/16-inch cross-section or an equivalent cross-section with a length equal to full height of fabric.

Provide steel truss rods that have a steel 3/8-inch diameter or equivalent cross-section and having suitable adjustment.

TABLE 710.03-1 STEEL POSTS, GATE FRAMES, AND POST BRACES

Usage – nominal fence height 6 ft or less	Section Thickness	Outside Diameter or Dimensions (in)	Weight Nominal lb/ft	Tolerance (+/- %)	Minimum Yield Strength (psi)
Line posts	Grade 1 Pipe	2.375	3.65	10	30,000
	Grade 2 Pipe	2.375	3.12	10	50,000
	C-Section	2.250 × 1.700	2.78	10	50,000
	H-Section	2.250 × 1.700	3.26	10	50,000
End, corner pull posts	Grade 1 Pipe	2.875	5.79	10	30,000
	Grade 2 Pipe	2.875	4.64	10	50,000
Gate Posts for nominal width of gate (single or one leaf of Double):					
Up to 6 ft incl.	Grade 1 Pipe	2.875	5.79	10	30,000
	Grade 2 Pipe	2.875	4.64	10	50,000
Over 6 to 13 ft incl.	Grade 1 Pipe	4.000	9.11	10	30,000
	Grade 2 Pipe	4.000	6.56	10	50,000
Over 13 to 18 feet incl.	Grade 1 Pipe	6.625	18.97	10	30,000
Over 18 feet	Round	8.625	28.58	10	30,000
Gate frames	Grade 1 Pipe	1.900	2.72	10	30,000
	Grade 2 Pipe	1.900	2.28	10	50,000
Tension Wire [1] post braces	Grade 1 Pipe	1.660	2.27	10	30,000
	Grade 2 Pipe	1.660	1.84	10	50,000
	Roll-form	1.6250 × 1.250	1.35	10	50,000
	Round tubing	1.660	1.38	10	50,000
[1] For specified tension wire, provide 0.177 in diameter.					

Provide ornamental cap post tops made of steel, malleable iron or cast iron. Provide them with a hole suitable for through passage of the top rail. Provide a snug fit to the post, attach securely to the post, and exclude moisture from tubular posts. Provide swing type gates complete with latches, stops, keepers, hinges, locks, and fabric. Cover them with fabric matching the fence. Provide hinges of adequate strength to support the gate and do not twist or turn under action of the gate. Locate plunger bar type latches at the full gate height to engage the gate stop. The Contractor may use forked latches for single gates less than 10 feet wide. Provide lockable latches. Provide stops consisting of a flush plate with anchor placed in concrete to engage the plunger bar of the latch. The Contractor may use other approved types of stops for single gates less than 10 feet wide. Use keepers for securing and supporting the free end of the gate in the open position.

Provide top rail couplings consisting of the outside sleeve type at least 6 inches long. Provide a minimum of 20 percent of the coupling with an internal heavy spring to take up expansion and contraction.

Provide gate frames assembled by welding, using properly designed, formed sheet, or sandcast fittings. Cover the gates with fabric matching the fence.

Provide offset type hinges. Provide galvanized latches, stops, and keepers made of malleable iron, except the Contractor may provide plunger bars of galvanized tubular or bar steel in accordance with Section 6.2.

Provide flat stretcher bars in 3/4 × 1/4-inch sections.

Provide self-centering outside rail couplings 6 inches long.

Provide tie wire having a 0.148-inch minimum diameter and meeting an aluminum alloy.

Provide wrought or cast turnbuckles.

Provide truss and brace rods with a 3/8-inch outside diameter or equivalent cross-section.

Provide beveled brace bands in 1 × 1/8-inch section.

Provide bolts with an anodic coating at least 2 mil in thickness, chromate sealed.

11.1 Provide the size of the fabric conforming to 0.148-inch nominal diameter of coated wire, 2-inch mesh.

14.1 Table 8. Provide Type I Zinc-Coated Steel Chain Link Fabric having Class D weight of coating.

15.5 Provide the vinyl covering of a uniform medium green color.

19.1 Perform inspection at the project site.

32.2 Does not apply.

32.3.3.2 Increase the minimum weight of interior coating to an average of 0.9 ounces per square foot and not less than 0.8 ounces per square foot on an individual specimen.

TABLE 710.03-2 DIAMETERS OR PLAIN END, SCHEDULE 40 ALUMINUM ALLOY PIPE

Material	**Nominal Pipe Size**
Brace rails	**(in)**
Gate frames and rail couplings	1 1/4
Line posts	1 1/2
End and corner posts	2
	2 1/2
Gate posts single or one leaf of double:	
Gate opening	
(ft)	**(in)**
To 6	2 1/2
Over 6 to 12	3 1/2
Over12 to 18	6
Over 18 to 32	8

Use the weights and dimensions as specified in ANSI H 35.2.

The Contractor may substitute an 8'8" line post in lieu of the line post shown on standard drawings Chain Link Fence 1.1, 7-28-00 and Walk Gates F-3.2, 7-28-00. Reduce the 4'-0" depth as necessary to accommodate the shorter posts. Use all other dimensions shown in the standard drawings

Provide certified material in accordance with ODOT Supplement 1067.

710.06 Deep Beam Rail. Provide deep beam rail in accordance with AASHTO M 180, Type II, Class A, with the following modifications:

5.1 Perform inspection at the project site.

5.2.1 If a field check of coating thickness shows insufficient coating thickness or shows insufficient coating weight, sample and test the guardrail.

9.1.2 The minimum check limits for both triple and single-spot tests apply.

Provide certified material in accordance with ODOT Supplement 1042.

710.09 Wire Rope Rail. Provide wire rope rail in accordance with AASHTO M 30, Class A, Type I rope, with the following modification:

9 Perform inspection at the project site.

Obtain random samples from material delivered to the project site or at other locations designated by the Laboratory.

710.11 Fence Posts and Braces. Provide round wood posts conforming to 710.12 and 710.14. Provide sound, straight dimension timber, posts, and lumber for braces and stream crossings, free from unsound or loose knots, splits and shakes, and treated in accordance with 712.06.

Provide steel line posts in accordance with ASTM A 702, with the following modifications:

5.5.2 Use fasteners or clamps having a 0.120-inch diameter and galvanized in accordance with ASTM A 116, Type Z, Class 3.

5.5.1 Supply each post with a sufficient number of fasteners or clamps.

6.2 Provide the designated post lengths.

7.1 Provide galvanized line posts and anchors in accordance with 711.02.

7.2 Delete.

Provide certified material in accordance with ODOT Supplement 1067.

710.12 Square-Sawed and Round Guardrail Posts. Provide pressure treated square-sawed and round guardrail posts in accordance with 710.14 and 712.06. Cut posts from growing timbers free from unsound or loose knots and rot and from injurious or excessive shake, and season checks that exceed 1/4 inch in width.

Ensure that the sweep does not exceed 1 inch for the length of the post. Peel round posts their entire length, removing all outer and inner bark and leather fiber by shaving the surface. Trim knots even with the post, and saw both ends of the post square.

Provide round posts for the follow species only:

A. Douglas Fir:

Knot diameter for posts of Douglas Fir shall not exceed 2 inches. Ring density for the species shall be at least 6 rings-per-inch as measured over a 3 inch distance. The diameter of the Douglas Fir posts shall be 7¼ inches at the ground line with a upper limit of 8 inches.

B. Southern Pine:

Knot diameter for posts of Southern Pine shall not exceed 2½ inches. Ring density for the species shall be at least 4 rings-per-inch as measured over a 3 inch distance. The diameter of the Southern Pine posts shall be 7½ inches at the ground line with an upper limit of 8¼ inches.

C. Ponderosa Pine:

Knot diameter for posts of Ponderosa Pine shall not exceed 4 inches. Ring density for the species shall be at least 6 rings-per-inch as measured over a 3 inch distance. The diameter of the Ponderosa Pine posts shall be 8 inches at the ground line with an upper limit of 8¾ inches.

Provide square sawed posts free from injurious cross grain and sapwood.

Species			White Pine	
Maximum Slope of Grain			1 in 15	
Nominal Width of Face			6"	8"
Shakes, Checks, and Splits	Green		1"	1 3/8"
	Seasoned		1 1/2"	2"
Maximum Wane			1"	1 3/8"
Maximum Allowable Knots	Narrow Face	Middle 1/3 of Length	1 3/8"	1 5/8"
		End (1)	2 3/4"	3 1/4"
		Sum in Middle ½ of Length (2)	11"	13"
	Wide Face	Edge Knot in Middle 1/3 of Length	1 3/8"	1 5/8"
		Edge Knot at End (1)	2 3/4"	3 1/4"
		Centerline	1 3/8"	1 7/8"
		Sum in Middle Half of Length	5 1/2"	7 1/2"

Provide certified material in accordance with ODOT Supplement 1072.

710.14 Pressure Treated Guardrail and Fence Posts, Braces, and Blocks. Provide pressure treated guardrail and fence posts, braces, and blocks in accordance with AASHTO M 168 and 710.11, 710.12, and 712.06.

Provide certified material in accordance with ODOT Supplements 1042 and 1072.

710.15 Steel Guardrail Posts. Provide steel guardrail posts in the sections and lengths as specified, made of copper bearing steel if specified. Provide steel in accordance with ASTM A 36. Furnish galvanized posts in accordance with 711.02.

Provide certified material in accordance with ODOT Supplement 1042.

710.16 Guard Posts. Provide pressure treated wood posts in accordance with 710.14. Provide posts either 5 × 6-inch sawed square or 5 1/2-inch + 1/2-inch diameter round when measured 30 inches from the top. Provide posts 5 feet, 3 inches in length embedded with 30 inches of post remaining exposed. Provide the center-to-center spacing of 6 feet intervals, unless otherwise shown on the plans.

Provide certified material in accordance with ODOT Supplement 1042.

ITEM 711 STRUCTURAL STEEL AND STRUCTURE INCIDENTALS

711.01 Structural Steel.
711.02 Galvanized Steel.
711.03 Steel for Piling.
711.04 Cold Rolled Steel.
711.07 Steel Castings.
711.08 Arc-Welding Electrodes and Fluxes.
711.09 High-Strength Steel Bolts, Nuts, and Washers.
711.10 Machine Bolts.
711.12 Gray Iron Castings.
711.13 Ductile Iron Castings.
711.14 Gray Iron and Ductile Iron Castings.
711.15 Sheet Copper.
711.16 Phosphor Bronze Plate.
711.17 Cast Bronze.
711.18 Leaded Bronze.
711.19 Sheet Lead.
711.20 Aluminum for Railings.
711.21 Preformed Bearing Pads.
711.22 Buried Liner Waterproofing Membrane.
711.23 Elastomeric Bearings.

711.24 Waterproofing Fabric.
711.25 Type 2 Membrane Waterproofing.
711.26 Structural Timber, Lumber and Piling.
711.27 Prestressing Steel Strands.
711.29 Type 3 Membrane Waterproofing.
711.30 Aluminum for Steps.
711.31 Reinforced Propylene Plastic Manhole Steps.
711.32 Elastomeric Strip Seal.
711.33 Performed Elastomeric Compression Seal.

711.01 Structural Steel. Provide structural steel conforming to ASTM A 709, Grade 36 (A36), 50 (A572), 50W (A588), or 70W.

Provide materials designated to meet notch toughness requirements having a minimum longitudinal Charpy V-Notch (CVN) energy absorption value as listed below. Sample and test in accordance with ASTM A 673. Use the (H) frequency of heat testing and provide the test data as required by 501.06.

ASTM Designation	Thickness and Connection Method	Value Min CVN
A709 Gr. 36 (A36)	Up to 4 in mechanically fastened or welded	15 ft-lb @ 40 °F
A709 Gr. 50 (A 572), A709 Gr. 50W (A 588)	Up to 4 in mechanically fastened	15 ft-lb @ 40 °F [1]
A709 Gr. 50 (A 572), A709 Gr. 50W (A 588)	Over 2 to 4 in welded	20 ft-lb @ 40 °F [1]
A709 Gr. 50 (A 572), A709 Gr. 50W (A 588)	Up to 2 in welded	15 ft-lb @ 40 °F [1]
A709 Gr. 70W	Up to 4 in mechanically fastened or welded	25 ft-lb @ -10 °F [2,3]

[1] If the yield point of the material exceeds 65 ksi, the temperature of the CVN value for acceptability should be reduced by 15 °F for each increment, or part of increment, of 10 ksi above 65 ksi.
[2] If the yield point of the material exceeds 85 ksi, the temperature of the CVN value for acceptability should be reduced by 15 °F for each increment, or part of increment, of 10 ksi above 85 ksi.
[3] The CVN-impact testing shall be at "P" frequency in accordance with ASTM A673.

711.02 Galvanized Steel. Provide galvanize steel in accordance with ASTM A 123 after cutting, bending, and welding. At the discretion of the Engineer, replace, re-galvanize, or repair damaged galvanized material. If the City authorizes a repair, perform work in accordance with ASTM A 780 except the City will not allow aerosol spray applications of paints containing zinc dust.

Provide bolts, nuts, washers, and similar threaded fasteners galvanized in accordance with ASTM A 153 or F2329. The Contractor may mechanically zinc coat in accordance with ASTM B 695, Class 50. Except for ASTM A 325 bolts, the Contractor may electrogalvanize the coated items meeting the thickness coating requirements of ASTM A 153 or F2329.

Use a chromate treatment on all galvanized parts embedded in fresh concrete except chairs for reinforcing bar support in accordance with the American Hot Dip Galvanizers Association, Inc. recommendations. Ensure the galvanizer provides a certification for each lot of chromate treated steel.

711.03 Steel for Piling. Provide steel for H-piling conforming to ASTM A 572 Grade 50. Provide steel for sheet piling in accordance with ASTM A 328. Provide steel for cast-in-place reinforced concrete piles conforming to ASTM A 252, Grade 2 or 3.

711.04 Cold Rolled Steel. Provide cold rolled steel in accordance with ASTM A 108, Grades 1016 through 1030 for pins, rollers, trunnions, and other similar parts.

711.07 Steel Castings. Provide steel castings in accordance with ASTM A 27, Grade 65-35 or Grade 70-36, or AASHTO M103, or ASTM A 148, Grade 90-60, with the following modification:

Provide steel castings free from pouring faults, sponginess, cracks, blow holes, and other defects in positions affecting their strength and value for the service intended. The Engineer will not allow sharp, unfilleted angles or corners.

711.08 Arc-Welding Electrodes and Fluxes. The following applies to all steel, except for exposed bare ASTM A 242 and ASTM A709 Grade 50W (A 588) steels. For exposed bare ASTM A 242and A709 Grade 50W (A 588) applications, see Table 711.08-1.

A. Manual shielded metal-arc welding.

1. AWS A5.1 Low Hydrogen Only
2. AWS A5.5 Low Hydrogen Only

B. Submerged Arc Welding.

1. AWS 5.17[5]

2. AWS 5.23[5]

C. Gas metal-arc welding, AWS A 5.18[5]

D. Flux cored arc welding, AWS A5.20[5]

TABLE 711.08-1
Filler metal requirements for exposed bare applications of
ASTM A 242and ASTM A709 Grade 50W (A 588) steel.

Welding Process

Shielded metal arc	**Submerged arc [5]**	**Gas metal arc or Flux cored arc [2], [4], [5]**
AWS A5.5	AWS A5.23	AWS A5.28 and 5.29
E8015, 8016, or 8018 electrodes that deposit weld metal meeting C1, C1L, C2, C2L, C3, or W analysis	All electrode-flux combinations that deposit weld metal with a Ni1, Ni2, Ni3, Ni4, or W analysis [2], [3]	All electrode-flux combinations that deposit weld metal with a Ni1, Ni2, Ni3, Ni4, or W analysis

[2] Deposited weld metal will have a minimum impact strength of CVN 20 ft-lb at 0 °F (only applied to bridges).
[3] The use of the same type filler metal having next higher mechanical properties as listed in AWS specification is permitted.
[4] Deposited weld metal will have a chemical composition the same as that for any one of the weld metals in this table for the shielded metal arc welding process.
[5] In conformance with those classifications allowed under AWS D1.5 *Bridge Welding Code*, Tables 4.1 and 4.2.

The Laboratory will issue a list of approved electrodes and combinations of shielding. The Laboratory will include electrodes in the list when the City finds certified test data submitted by the manufacturer in compliance with the specified requirements. The certification will cover either process qualification or quality control tests. To qualify, provide tests made within one year before the period covered. For each submission of certified test data, include the manufacturer's statement that the manufacturer will advise the Laboratory immediately of any change in materials or processing used in the manufacture of the electrodes made within one year from the date of the tests.

When using electrodes not included in the Laboratory's list of approved electrodes and combinations of shielding, submit certified test data as described above for each lot showing compliance with the specified requirements.

711.09 High-Strength Steel Bolts, Nuts, and Washers. Provide high-strength steel bolts, nuts, and washers in accordance with ASTM A 325, with the following modification:

11 If necessary for approval, obtain samples from material delivered to the project site or at other locations designated by the Laboratory.

Provide bolts for steel use in bare unpainted applications in accordance with A 325, Type 3.

When the specifications call for galvanized bolts, nuts, and washers, the Engineer will allow mechanical galvanizing.

Use galvanized bolts to fasten steel that has received an inorganic zinc prime coat in accordance with 514.

Provide high-strength steel bolts, nuts, and washers that also meet the requirements of ODOT Supplement 1080.

Provide samples to the Laboratory for acceptance.

711.10 Machine Bolts. Provide machine bolts in accordance with ASTM A 307, with the following modification:

If necessary for approval, obtain samples from material delivered to the project site or at other locations designated by the Laboratory.

The Engineer will allow mechanical galvanizing.

711.12 Gray Iron Castings. Provide gray iron casting in accordance with ASTM A 48, Class 35B, with the following modifications:

12 Submit two or more test bars with each lot of castings or; one pair of test bars may represent castings shipped to two or more projects provided both the bars and castings show the lot number or date cast or anchored into them. Do not allow the identifying data or castings to interfere with the use of the casting.

9 Provide castings free from pouring faults, sponginess, cracks, blow holes, and other defects in positions affecting their strength and value for the service intended. Provide castings generously filleted at angles and the arrises are sharp and perfect.

17 Ship test bars with the lot or make test bars representing the lot available to the Laboratory at the place of manufacture or warehouse.

711.13 Ductile Iron Castings. Provide ductile iron castings in accordance with ASTM A 536, with the following modifications:

8.1 Provide castings free from pouring faults, sponginess, cracks, blowholes, and other defects in positions affecting their strength. Provide castings generously filleted at sharp and perfect angles and arises.

10.1 Send a keel block or Y-block specimen made in accordance with ASTM A 536 with the shipment for each heat number, ladle number, and date of casting.

14.1 Submit a certification stating that the Contractor prepared the test bars shipped with the castings in accordance with the specified requirements.

711.14 Gray Iron and Ductile Iron Castings. Provide gray iron and ductile iron castings in accordance with AASHTO M 306, Class 35B, with the following modifications:

Provide test bars as required in Section 711.12 and Section 711.13. In addition, submit certified test data for monthly proof load testing to the Laboratory with each inspection of castings from that month.

Design Approval. Submit designs for cast frames, grates and covers for manholes, catch basins and inlets that vary from the standard drawings to the City for approval. The City suggests that manufacturers seek approval for such non-standard designs well in advance of a project's bid opening date.

711.15 Sheet Copper. Provide sheet copper in accordance with in accordance with ASTM B 370.

711.16 Phosphor Bronze Plate. Provide phosphor bronze plate in accordance with ASTM B 100.

711.17 Cast Bronze. Provide cast bronze in accordance with ASTM B 22, Copper Alloy No. C91100, with the following modification:

Finish cast plates to plane surfaces and finish one plate of a pair at right angles to the other plate of the pair.

711.18 Leaded Bronze. Provide leaded bronze in accordance with in accordance with ASTM B 584, Copper Alloy No. C93700, with the following modification:

Finish cast plates to plane surfaces and finish one plate of a pair at right angles to the other plate of the pair.

711.19 Sheet Lead. Provide sheet lead in accordance with in accordance with ASTM B 29.

711.20 Aluminum for Railings. Provide aluminum other than permanent mold castings conforming to the following requirements:

Portion of Railing	ASTM Designation	Alloy	Condition or Temper (B296)
Sand castings	B 26	356.0	T6
Shims	B 209	1100	0
Washers	B 209	Clad 2024 6061	T4 T6
Sheet and plate	B 209	6061	T6
Drawn seamless tubes	B 210	6061 or 6063	T6
Bars, rods, wire	B 211	6061	T6
Bolts set screws	B 211	2024 [1] 6061	T4 T6
Nuts	B 211	6061 6262	T6 T9
Extruded bars, rods, shapes	B 221	6061 or 6063 6351	T6 T5
Extruded tubes	B 221	6061 or 6063 6351	T6 T5
Pipe	B 241	6061 or 6063	T6
Rivets	B 316	6061	T6
[1] Requires an anodic coating.			

For permanent mold castings for bridge railing posts, provide aluminum according to AASHTO M 193.

711.21 Preformed Bearing Pads.

A. Composition. Provide preformed bearing pads consisting of a fabric and rubber body. Make the pad with new, unvulcanized, natural and/or synthetic rubber, and unused cotton and/or synthetic fabric fibers in proper proportion to maintain strength and stability.

B. Physical Properties. The City requires a surface hardness, expressed in standard rubber hardness figures, of 80 ± 10 Shore Durometer. The City will allow a minimum ultimate break down limit of pads under compressive loading of 10,000 pounds per square inch. Provide pads to specified dimensions and accurately locate and cleanly cut all bolt holes.

Provide materials in accordance with the City's QPL.

711.22 Buried Liner Waterproofing Membrane. Provide buried liner waterproofing membrane in accordance with ASTM D 7176-06, with the following modification:

The City only approves the use of Section 4.1.2 through Section 4.1.6.

Provide materials in accordance with the City's QPL.

711.23 Elastomeric Bearings. Provide bearing pads and elastomeric bearings conforming to *AASHTO Standard Specifications for Highway Bridges*, Division II, Construction, Chapter 18, Section 18.4.5.1 Grade 3 requirements. Fabricate elastomeric bearing pads according to Sections

18.5.6.1 and 18.5.6.2. Test pads and bearings in accordance with 18.7.1, 18.7.2.1, 18.7.2.3, 18.7.2.5, 18.7.2.6, 18.7.3, 18.7.4.5, and 18.10.3. Include testing in the contract unit price for the bearings. Provide certified material in accordance with ODOT Supplement 1081.

Provide bearing pads and laminated bearings consisting of neoprene cast in molds under pressure and heat. The City classifies a plain elastomeric bearing pad and steel load distribution plate combination as a laminated elastomeric bearing. Obtain test specimens in accordance with ASTM D 3182 or ASTM D 3183. For test specimens cut from the finished product, the Engineer will allow a 20 percent variation from the original physical properties. The Engineer will allow the use of compounds of nominal hardness between the values shown in Table 711.23-1 and will interpolate the test requirements.

TABLE 711.23-1

Physical Properties	**Grade**		
	50	**60**	**70**
Hardness, Durometer A, ASTM D 2240.	50 ± 5	60 ± 5	70 ± 5
Tensile Strength, min psi, ASTM D 412	2500	2500	2500
Elongation at break, min %	400	350	300
Accelerated Tests to Determine Long-Term Aging Characteristics, Over-Aged 70 hrs at 212 °F, ASTM D 573:			
Hardness, points change, max	15	15	15
Tensile strength, % change, max	-15	-15	-15
Elongation at break, % change, max	-40	-40	-40
Ozone 1 ppm in air by volume 20% strain, 104 °F ASTM D 1149, 100 hrs (Wipe samples with solvent before test to remove any traces of surface impurities)	No cracks	No cracks	No cracks
Compression set 22 hrs/212 °F ASTM D 395, Method B, % max	35	35	35
Adhesion, bond made during vulcanization ASTM D 429 Method B, lb/in	40	40	40

Provide individually molded bearing pads, cut from previously molded strips or slabs, or extruded and cut to length. Mold laminated bearings together into an integral unit with all edges of internal steel laminates covered by a 1/8-inch minimum thickness of elastomer. Fill indentations or grooves on the exterior surface of the bearings caused by external laminate restraining devices to a 1/8 inch minimum cover by a revulcanized patch; or by a silicon caulk conforming to Federal Specifications TT-S-001543A; or by an approved equal. Ensure that the bearing manufacturer patches the bearings.

Provide external connection or distribution plates of laminated bearings having the same material as the attached structural steel, similarly cleaned and coated. Provide internal plates in accordance with ASTM A 709 grade 36 or A1011, SS Grade 36 or Grade 40. With a minimum thickness for the internal plates of 0.074 inch. Debur all plates.

Provide the bearing manufacturer's certified test data for the elastomer, base plate, steel laminates, and proof load.

The bearing manufacturer will produce one sample bearing for each bridge structure in the project plans. Provide the sample bearing for each bridge structure of the same design and materials as the bearings provided for that bridge structure. The bearing manufacturer will ship the completed sample bearings to an independent testing laboratory for destructive testing for the following physical properties:

Hardness, Durometer A	ASTM D2240
Tensile Strength	ASTM D412
Elongation at Break	ASTM D412
Adhesion bond made during vulcanization	ASTM D429, Method B

Submit to the Engineer the bearing manufacturer's certified test data for the sample bearings from the independent testing laboratory with the bearing manufacturer's certified test data for the elastomer, base plate, steel laminates, and proof load.

711.24 Waterproofing Fabric. Provide waterproofing fabric in accordance with ASTM D 173

Provide materials in accordance with the City's QPL.

711.25 Type 2 Membrane Waterproofing.

Physical Properties	
Thickness ASTM D 1777	60 mils min.
Width	36 inches min.
Pliability [180° bend over 1/4 inch mandrel @ -25 °F] ASTM D 146	No Effect
Elongation ASTM D 412 (Die C)	300% min
Puncture Resistance-Membrane ASTM E 154	40 lb min.
Permeance (Grains/ft^2/hr/in Hg) ASTM E 96, Method B	0.1 max.
Water Absorption (% by Weight) ASTM D 570	0.2 max.
Adhesion to concrete ASTM D 903	5.0 min.

Submit certified test data and letter of certification to the Engineer.

Provide materials in accordance with the City's QPL.

711.26 Structural Timber, Lumber and Piling. Provide structural timber, lumber and piling in accordance with 712.06, and AASHTO M 168, with the following modification:

Air-dry or kiln-dry timber and lumber to a moisture content not exceeding 19 percent by weight. Use lumber with size and grade conforming to American Lumber Standards.

Use only structural timber, lumber, and piling meeting the certification requirements of ODOT Supplement 1072.

711.27 Prestressing Steel Strands. Provide prestressing steel strands in accordance with ASTM A 416, with the following modification:

11 Sample and inspect as directed by the Laboratory.

711.29 Type 3 Membrane Waterproofing. Provide Type 3 membrane waterproofing conforming to the following requirements.

Physical Properties	
Thickness	0.135 inches min.
Width	36 inches min.
Weight	0.8 lb/ft2 min.
Tensile strength (machine direction) ASTM D 882 Modified [1]	275 lb/in 200 psi
Tensile strength ASTM D 882 (90° machine direction) Modified [1]	150 lb/in 1000 psi
Elongation at break ASTM D 882, Modified [1]	100%
Brittleness ASTM D 517	Pass
Softening point (mastic) ASTM D 36	200 °F min.
Peel adhesion ASTM D 413 [1]	2.0 lb/in
Cold flex ASTM D 146 2 × 5 inchspecimen-180° bend over 2 inch mandrel	No cracking
Heat stability 2 × 5 inch specimen vertically suspended in a mechanical convection oven 2 hr @ 190 °F	No dripping or delamination
[1] 12 inches/minute test speed and 1 inch initial distance between the grips.	

Submit certified test data and letter of certification to the Engineer.

Provide materials in accordance with the City's QPL.

711.30 Aluminum for Steps. Provide aluminum for steps in accordance with ASTM B 221, Alloys 6061-T6 or 6005-T5.

Provide materials in accordance with the City's QPL.

711.31 Reinforced Propylene Plastic Manhole Steps. Provide reinforced propylene plastic manhole steps conforming to the details shown on the plans and in accordance with ASTM C 478.

Provide steel rod in accordance with 709.01, Grade 60, continuous through the entire length of legs and tread. The steel may be coated in accordance with ASTM A 934. Submit the manufacturer's written certification to the Engineer. Provide propylene plastic in accordance with ASTM D 4101, Table B 33430. Submit to the Engineer the manufacturer's certified test data for the propylene plastic used in each lot of steps.

Furnish materials according to the City's QPL.

711.32 Elastomeric Strip Seal. Provide elastomeric strip seals in accordance with ASTM D5973.

711.33 Performed Elastomeric Compression Seal.

A. General. Provide preformed elastomeric compression seals in accordance with ASTM D3542, with the following modifications:

5.1 Provide the size and design as shown on the plans.

7.2 The Engineer will perform inspection at the project site.

7.3 If sampled, provide a minimum of 3 feet, with all manufacturers' markings.

12.1 In addition, provide markings every 1 foot. Use lubricants recommended by the seal manufacturer to install preformed compression seals.

B. Qualification. Obtain City approval of each design, shape, width, depth, web, and shell thickness before use. Submit drawings of the seals showing all dimensions and dimension tolerances and weight per foot with the request for approval.

ITEM 712 MISCELLANEOUS

712.01 Expansion Shield Anchors.
712.02 Calcium Chloride.
712.03 Sodium Chloride.
712.04 Lime.
712.06 Preservative Treatment for Structural Timber, Lumber, Piling, Posts, Braces, and Blocks.
712.09 Geotextile Fabrics.
712.10 Prefabricated Edge Underdrain.
712.11 Temporary Erosion Control Mats Materials.
712.12 Tied Concrete Block Mat.
712.13 Articulating Concrete Block Revetment System.
712.14 Detectable Warning Devices.

712.01 Expansion Shield Anchors. Provide anchors conforming to the dimension requirements of the project plans and the following:

A. Type A. Federal Specification A-A-1923A, and A-A-55614.

B. Type B. Federal Specification A-A-1924A.

The supplier or producer of the anchors will provide a certification showing certified test results of the proof load required in the Federal Specification.

Provide materials in accordance with the City's QPL.

712.02 Calcium Chloride. Provide calcium chloride in accordance with ASTM D 98.

Provide materials in accordance with the City's QPL.

712.03 Sodium Chloride. Provide sodium chloride in accordance with ASTM D 632, Type I, Grade 1, with the following modification:

4 Total Chlorides (NaCl, $CaCl_2$, and $MgCl_2$ as NaCl based on dry weight) not less than 95 percent.

712.04 Lime.

A. Provide hydrated lime for masonry purposes in accordance with ASTM C 207, Type S.

B. Provide quick lime for soil stabilization certified in accordance with ODOT Supplement 1087, as listed on the City's QPL and in accordance with ASTM C 977, with the following modification:

4.2.1 *Particle size of Quick Lime* – Quick lime shall all pass the 3/8-inch (9.5 mm) sieve and at least 90 percent shall pass the No. 4 sieve.

712.06 Preservative Treatment for Structural Timber, Lumber, Piling, Posts, Braces, and Blocks.

A. General. Provide structural timber, lumber, and pilings in accordance with 711.26, and posts, braces, and blocks in accordance with 710.14 that the City will allow moisture removal from the untreated lumber at the time of preservative treatment. Ensure that the treatment of structural timber, lumber, piling, posts, and braces conform to the current AWPA standards or AASHTO M-133, and this subsection.

B. Materials. Furnish timber preservatives according to AASHTO M 133 and current AWPA standards.

C. Preparation for Treatment. Sort the material into one kind or designated group of kinds of wood and into pieces of approximately equal size and moisture and sapwood content. Separate material to ensure contact between treating medium and all surfaces.

D. Framing. Conduct all adzing, boring, chamfering, framing, graining, mortising, and surfacing before treatment.

E. Incising. Incise lumber 3 inches or more thick on all four sides. Incise lumber less than 3 inches thick on the wide faces only, except as shown on the plans.

Incise Douglas fir with a minimum dimension of 2 inches using a suitable power-driven machine before treatment. Do not incise Douglas fir rails and rail posts.

Use the spacing and shape of the cutting teeth and the method of incising necessary to produce a uniform penetration. Meet the minimum required depths of the incisions as follows:

Size[1]	Minimum depth of incision, inch
2 × 12	3/8
3 × 12	7/16
4 × 12	1/2
8 × 10	9/16
10 × 12	5/8
12 × 12	3/4

[1] Intermediate size in proportion.

F. Amount of Preservative. The Engineer will require net retention in any charge no less than 90 percent of the quantity of preservative specified. The Engineer will require the average retention by the material treated under any contract or order and the average retention of any five consecutive charges to be at least 100 percent of the quantity specified. Ensure that the minimum amounts of preservative retained conform to AASHTO M 133 and the requirements set forth in the referenced AWPA Standard. Treat all species of structural timber, lumber, piling, posts, and blocks in accordance with the current AWPA standards.

G. Acceptance. Accept only structural timber, lumber, piling, posts, braces, and blocks in accordance with ODOT Supplement 1072.

H. Sawn Wood Sign Posts. A swan wood post must adhere to AASHTO M 168: Wood Products standards, and be the allowable grade and species for the sizes shown in the following table:

Nominal Post Size [a]	Allowable grade and species
4 by 4 inches	No. 1 structural light framing Douglas fir, free of heart center
	No. 1 structural light framing Hem-Fir, free of heart center
	No. 1 structural light framing Southern Yellow pine
4 by 6 inches	No. 2 structural joists and planks Douglas fir, free of heart center
	No. 1 structural joists and planks Hem-Fir, free of heart center
	No. 1 structural joists and planks Southern Yellow pine
Greater than 4 by 6 inches	No. 1 posts and timbers, also known as No. 1 structural Douglas fir, free of heart center
	Select structural Hem-Fir, free of heart center
	No. 1 timbers Southern Yellow pine

[a] Sizes shown are nominal dressed sizes
The sweep must not exceed 0.08 foot in 10 feet.
Sawn wood sign posts must be graded per the following:
Southern Pine Inspection Bureau (SPIB) Standard Grading Rules
Western Wood Products Association (WWPA) Standard Grading Rules
West Coast Lumber Inspection Bureau (WCLIB) Standard Grading Rules
Posts must be treated per current AASHTO M 133: Preservatives and Pressure Treatment Processes for Timber standards.
Douglas fir and Hem-Fir posts must be incised prior to treatment.
Inspection shall be in accordance with AWPA M2.
Quality control shall be in accordance with AWPA M3.
Care of the posts shall be in accordance with AWPA M4.

712.09 Geotextile Fabrics. Provide fabric composed of strong rot-proof polymeric fibers formed into a woven or non-woven fabric. The City will determine acceptance of Type A, B, C and D fabric in accordance with data obtained in the most current NTPEP report – Laboratory Results of Evaluations on Geotextiles and Geosynthetics.

For Type E material, supply fabric conforming to the requirements of AASHTO M288, Section 10, Table 8. The City will accept Type E material based on certified test data.

All minimum strengths shown are in the weakest principal direction.

Provide fabric free of any treatment that might significantly alter its physical properties.

During shipment and storage, wrap the fabric in a heavy-duty protective covering to protect it from UV deterioration, direct sunlight, dirt, dust, and other debris.

Provide Type A, B, C, and D material in accordance with the City's QPL and ODOT Supplement 1123.

TABLE 712.09-1

Property	Test Method	Required Value	
Type A: Underdrains and Slope Drains			
Minimum tensile strength	ASTM D 4632	80 lb	
Minimum puncture strength [1]	ASTM D 6241	140 lb	
	or ASTM D 4833	25 lb	
Minimum tear strength	ASTM D 4533	25 lb	
Apparent opening size	ASTM D 4751		
Soil Type-1: Soils with 50% or less passing No. 200 sieve		AOS ≤ 0.6 mm	
Soil Type-2: Soils with 50 to 85% passing No. 200 sieve		AOS ≤ 0.3 mm	
Minimum permittivity	ASTM D 4491	0.5 sec^{-1}	
Type B: Filter Blankets for Rock Channel Protection			
Minimum tensile strength	ASTM D 4632	200 lb	
Minimum elongation	ASTM D 4632	15%	
Minimum puncture strength [1]	ASTM D 6241	440 lb	
	or ASTM D 4833	80 lb	
Minimum tear strength	ASTM D 4533	50 lb	
Apparent opening size	ASTM D 4751	AOS ≤ 0.6 mm	
Minimum permittivity	ASTM D 4491	0.2 sec^{-1}	
Type C: Sediment Fences			
Minimum tensile strength	ASTM D 4632	120 lb	
Maximum elongation	ASTM D 4632	50%	
Minimum puncture strength [1]	ASTM D 6241	275 lb	
	or ASTM D 4833	50 lb	
Minimum tear strength	ASTM D 4533	40 lb	
Apparent opening size	ASTM D 4751	AOS ≤ 0.84 mm	
Minimum permittivity	ASTM D 4491	0.01 sec^{-1}	
Ultraviolet exposure strength retention [2]	ASTM D 4355	70%	
Type D: Subgrade Base Separation or Stabilization			
Minimum tensile strength	ASTM D 4632	180 lb	
Maximum elongation	ASTM D 4632	50%	
Minimum puncture strength [1]	ASTM D 6241	385 lb	
	or ASTM D 4833	70 lb	
Minimum tear strength	ASTM D 4533	70 lb	310 N
Apparent opening size	ASTM D 4751	Same as Type A	
Permittivity	ASTM D 4491	0.05 sec^{-1}	

[1] ASTM D6241 is now the standard puncture resistance test required by AASHTO and NTPEP. NTPEP will continue to publish product data, tested under ASTM D4833, until the product is retested under ASTM D6241.
[2] Provide certified test data to the City. Include strength retention data at 0, 150, 300, and 500 hours

712.10 Prefabricated Edge Underdrain. Provide prefabricated edge underdrain consisting of a polymeric core with a minimum thickness of 1 inch wrapped in fabric in accordance with 712.09, Type A. Provide a flexible underdrain, rectangular in shape, and of hollow construction. Use core material resistant to petroleum-based chemicals, naturally occurring soil chemicals, and road de-icing agents. Provide core material having sufficient flexibility to withstand bending and handling during installation without damage. Provide a core with a minimum of 100 square inches unobstructed (one side only) drainage area per 1 foot of width. Provide side walls of the core having at least 5 percent open area to permit unobstructed flow through the filter and wall to the core. The Engineer will require prefabricated edge drain with 6000 pounds per square foot with a maximum 20 percent compression in a parallel plate compression test (ASTM D 695) minimum compressive strength. Provide a minimum (single side) core flow capacity of 10 gallons per minute per foot of width for a 0.1 gradient at 10 pounds per square inch bladder load in accordance with ASTM D 4716. Provide the manufacturer's certified test results as specified 101.03.

712.11 Temporary Erosion Control Mats Materials. Unless specifically itemized, provide any of the type mats listed below. Provide certified test data for each shipment of material.

A. Type A Temporary Erosion Control Mat. Provide a Type A temporary erosion control mat conforming to the following:

1. A machine-produced mat consisting of 100 percent agricultural straw covered on the top with a polypropylene netting having an approximate 1/4 × 1/4 inch to 1/2 × 1/2 inch mesh, and sewn together with biodegradable or photodegradable thread.

2. A consistent thickness with the straw evenly distributed over the entire area of the mat.

3. A minimum mat width of 6.5 feet.

4. An average mat weight of 0.5 pound per square yard ± 10 percent.

5. A netting weight of approximately 1 pound per 1000 square feet.

B. Type B Temporary Erosion Control Mat. Provide a Type B temporary erosion control mat conforming to the following:

1. A machine-produced mat consisting of 100 percent agricultural straw covered on the top with a photodegradable polypropylene netting having an approximate 1/2 × 1/2 inch to 5/8 × 5/8 inch mesh and on the bottom with a photodegradable polypropylene netting having an approximate 1/4 × 1/4 inch to 1/2 × 1/2 inch mesh, sewn together with biodegradable or photodegradable thread.

2. A consistent thickness with the straw evenly distributed over the entire area of the mat.

3. A minimum mat width of 6.5 feet.

4. An average mat weight of 0.5 pound per square yard ±10 percent.

5. A top netting weight of approximately 3 pounds per 1000 square feet and a bottom netting weight of approximately 1 pound per 1000 square feet.

C. Type C Temporary Erosion Control Mat. Provide a Type C temporary erosion control mat conforming to the following:

1. A machine-produced mat consisting of 70 percent agricultural straw and 30 percent coconut fiber covered on the top with a photodegradable polypropylene netting having an approximate 5/8 × 5/8 inch mesh and on the bottom with a photodegradable polypropylene netting having an approximate 1/4 × 1/4 inch mesh, sewn together with cotton thread.

2. A consistent thickness with the straw and coconut fiber evenly distributed over the entire area of the mat.

3. A minimum mat width of 6.5 feet.

4. An average mat weight of 0.5 pound per square yard ± 10 percent.

5. A top netting weight of approximately 3 pounds per 1000 square feet and a bottom netting weight of approximately 1 pound per 1000 square feet.

E. Type E Temporary Erosion Control Mat. Provide a Type E temporary control mat conforming to the following:

1. A machine-produced mat consisting of 100 percent coconut fiber covered on the top and bottom with an ultraviolet stabilized polypropylene netting having an approximate 5/8 × 5/8 inch mesh, and sewn together with polyester thread.

2. A consistent thickness with the coconut fiber evenly distributed over the entire area of the mat.

3. A minimum mat width of 6.5 feet.

4. An average mat weight of 0.5 pound per square yard ± 10 percent.

5. An ultraviolet stabilized polypropylene netting with a weight of approximately 3 pounds per 1000 square feet.

F. Type F Temporary Erosion Control Mat. Provide a Type F temporary erosion control mat conforming to the following:

1. A uniform open plain weave of undyed and unbleached single jute yarn.

2. Loosely twisted yarn not varying in thickness by more than one-half its normal diameter.

3. Provide mats in rolled strips with:

   a. A minimum length of 50 yards.

   b. A width of 48 inches ± 1 inch.

   c. Warp ends width 81 ± 3.

   d. Weft ends per yard (meter) 41 ± 3.

   e. An average weight of 1.22 pounds per linear yard ± 10 percent.

G. Type G Temporary Erosion Control Mat. Provide a Type G temporary erosion control mat conforming to the following:

1. A machine-produced mat consisting of wood excelsior, with 80 percent at least 8 inches in length.

2. Excelsior cut from properly cured wood to achieve adequately curled and barbed fibers.

3. A consistent thickness with the fiber evenly distributed over the entire area of the mat.

4. For use in ditches or channels, cover the top and bottom of the excelsior with lightweight netting entwined with the excelsior for maximum strength and ease of handling, or cover the top only with heavyweight netting machine sewn on maximum 2 to 4-inch centers along the longitudinal axis of the material. For all other applications, cover the top with lightweight netting entwined with the excelsior for maximum strength and ease of handling.

5. Regardless of application, lightweight netting consists of either netting having a maximum 3 × 1 inch weave, twisted craft [check spelling] paper yarn having a high web strength or biodegradable plastic.

6. Mat widths of 24, 36, 48, or 78 inches or greater, ±1 inch.

7. Mat rolls of more than 90 feet in length.

8. A mat weight of not less than 0.72 pound per square yard constant weight, air dry.

I. Type I Temporary Erosion Control Mat. Provide a Type I temporary control mat conforming to the following:

1. Extruded polymeric plastic net having a mesh opening of approximately 3/4 × 3/4 inch.

2. A netting with an average weight of 3 pounds per 1000 square feet ± 10 percent and a minimum tensile strength of 15 pounds over a 3-inch width in the weakest principal direction.

712.12 Tied Concrete Block Mat. Furnish materials tested to ASTM D6460. The City will determine acceptance of Type 1, 2, and 3 based on independent third party test data. The acceptable stability threshold shear values are:

Type 1: 3 lbf/ft²
Type 2: 5 lbf/ft²
Type 3: 7 lbf/ft²

Furnish products according to the City's QPL.

712.13 Articulating Concrete Block Revetment System. Furnish materials according to ASTM D6684 and tested according to ASTM D7277. The City will determine acceptance of Type 1, 2, 3 based on independent third party test data. The acceptable stability threshold shear values are:

Type 1: 17 lbf/ft²
Type 2: 20 lbf/ft²
Type 3: 23 lbf/ft²

Furnish products according to the City's QPL.

712.14 Detectable Warning Devices. Furnish materials conforming to the following requirements:

Products must be compliant with the Department of Justice 2010 Standards for Accessible Design, Section 705 or the most current update.

Products may be manufactured from materials of cast iron, stainless steel, polymer concrete, reinforced polymer composite, or granite. Products may be designed as either one time installation products or replaceable products.

Stamped concrete will not be permitted.

Detectable Warning Devices will be provided with a minimum 5 year written warranty with at least the following:

A. The installed device will remain compliant with the Department of Justice 2010 Standards for Accessible Design, Section 705, for the term of the warranty period.

B. During the warranty period at least 85% of the truncated domes on installed device will remain entirely intact.

C. The installed device will remain securely affixed to and flush with the concrete substrate for the warranty period.

D. At no cost to the City, the manufacturer will replace the product, including all installation costs, if during the 5 year warranty period the product fails to comply with the above warranty requirements. Any new device installed under the warranty will meet the requirements of this specification.

Furnish materials according to the City's Approved Products List.

Begin warranty period upon Contract acceptance.

At the preconstruction meeting, provide the Engineer with the written warranty signed by the executive officer of the manufacturing company.

ITEM 719 DELINEATOR MATERIALS

719.01 Reflectors.
719.03 Flexible Posts.
719.04 Break Away Bollards.
719.05 Longitudinal Channelizers.

719.01 Reflectors. For bridge parapet bracket or bridge rail bracket, furnish rectangular reflectors that are a minimum size of 3 × 6 inches and that consist of reflective sheeting according to 730.192 or 730.193 adhered to an aluminum plate. Furnish white, yellow, or red reflectors as specified. Furnish aluminum plate for reflectors according to ASTM B 209, 6061-T6 with a minimum thickness of 0.060 inch.

For ground mounted delineators, furnish rectangular reflective sheeting according to 730.192 or 730.193 that is a minimum size of 3 × 6 inches adhered to a flexible post. Furnish white, yellow or red reflectors as specified.

For surface mounted delineators, furnish a 3-inch wide band of reflective sheeting according to 730.192 or 730.193 adhered completely around a flexible post. Furnish white or yellow reflectors as specified.

Furnish materials according to the City's Qualified Products List (QPL).

719.03 Flexible Posts. Provide flexible posts conforming to ODOT Supplement 1020.

Provide materials in accordance with the City's QPL.

719.04 Break Away Bollards. Provide break away bollards conforming to the City of Columbus Standard Drawing 2195.

Break away bollards shall consist of a square steel tubing installed through the pavement and/or placed directly into the ground. Treated wood posts placed in steel tubing with reflective sheeting wrapped at the top for Type A bollards, and Type B bollards shall have reflective sheeting applied to the panels mounted at the top.

719.05 Longitudinal Channelizers. Furnish materials that conform to the following requirements.

Product shall be a Category A Lane Separator Longitudinal Channelizer System of interlocking raised units, profile depicting retro-reflective arcs and reboundable vertical markers/bollards.

Provide Longitudinal Channelizer System with separator units that can receive flat markers or bollards.

All materials shall meet the requirements set forth in the NCHRP 350 or MASH 08.

Furnish materials according to the City's Approved List.

ITEM 720 PLASTIC PIPE

720.01 Thermoplastic Pipe for Sewers and Other Gravity Flow Applications.
720.02 Plastic Pipe Fittings.
720.03 Pipe Markings.
720.04 Testing.
720.05 Testing Equipment.
720.06 Miscellaneous.
720.07 Smooth-Wall Polyvinyl Chloride Underdrain Pipe.
720.08 Polyvinyl Chloride Solid Wall Pipe.
720.09 Polyvinyl Chloride Large Diameter Plastic Solid Wall Pipe.
720.10 Polyvinyl Chloride Corrugated Smooth Interior Pipe.
720.11 Polyvinyl Chloride Closed Profile Wall Pipe.
720.12 Corrugated Polyethylene Smooth Lined Pipe.
720.13 Polypropylene Corrugated Double Wall Pipe.
720.14 Polypropylene Triple Wall Pipe.
720.15 Glass-Fiber-Reinforced Polymer Mortar Pipe. Provide glass-fiber-reinforced
720.16 Polyvinyl Chloride (PVC) Pipe.

720.01 Thermoplastic Pipe for Sewers and Other Gravity Flow Applications. Provide all plastic sewer pipe and accessories conforming to the requirements in this section and the stated requirements published in the current applicable ASTM Standards and Manufacturers Specifications. The Engineer will not allow plastic sewer pipe 1 year or older for use on City projects, unless the City has a letter on file from the manufacturer authorizing an additional 1 year exposure life. The City will maintain a list of current Approved Manufacturers, Product Types and Sizes, and Authorization Letters at the City's testing facility.

720.02 Plastic Pipe Fittings. Provide all fittings conforming to the applicable ASTM, AASHTO, and Manufacturer's Specifications.

720.03 Pipe Markings. Legibly mark all pipe with the information required in the ASTM Standards, except indicate production dates by the standard calendar date (day-month-year) or Julian Date with the current numerical year.

720.04 Testing. The Engineer will select random samples of pipe for each size proposed for use on City projects for testing from either the Producer or Suppliers yard a minimum of three (3) times per calendar year. Make samples available from all plants that may furnish pipe to City project. As directed by the City, test the samples at either the City's testing laboratory or manufacturer's facility for physical and dimensional conformance per the applicable ASTM and/or AASHTO Specifications. The City will prohibit use of sizes not submitted for testing, or failing to meet the requirements on City projects until retested and approved during the next testing consignment. The Engineer will allow one retest for each failed size during each consignment at no additional cost to the City. The Contractor may obtain random samples from materials delivered to the project site or at locations designated by the testing authority for additional conformance verification.

720.05 Testing Equipment. Require the manufacturer furnishing plastic pipe under these specifications to provide facilities and personnel available to perform tests if requested by the Engineer.

720.06 Miscellaneous. The Engineer will not allow solvent cement joints.

720.07 Smooth-Wall Polyvinyl Chloride Underdrain Pipe. Provide smooth wall perforated PVC plastic pipe and fittings with nominal size of 4, 6, and 8-inch diameter in accordance with ASTM F 758, Type PS 46 minimum, with the following modifications:

7.2.4 Provide pipe having a minimum of four rows of perforations.

720.08 Polyvinyl Chloride Solid Wall Pipe. Provide PVC solid wall pipe and fittings with nominal sizes of 4, 6, 8, 10, 12 and 15-inch diameter in accordance with ASTM D 3034, SDR 35, with the following modifications:

9.1 Perform inspection at the project site.

10.1 The retest provisions do not apply.

11.1 Provide certified test data as defined in 101.03 to the Engineer.

Provide fittings conforming to ASTM F-1336.

720.09 Polyvinyl Chloride Large Diameter Plastic Solid Wall Pipe. This specification consists of requirements for smooth wall (PVC) plastic pipe and fittings for sizes 18 through 36 inches diameter. Provide pipe and fittings conforming to ASTM F-679, with the following modifications:

8.1 The retest provisions do not apply.

720.10 Polyvinyl Chloride Corrugated Smooth Interior Pipe. Provide PVC profile wall pipe with a smooth interior consisting of an outer corrugated wall fused to a smooth inner wall. Use nominal sizes of 4, 6, 8, 10, 12, 15, 18, 21, 24, 27, 30, 36, 42, & 48-inch diameter included for pipe, joints, and fittings. Provide sewer pipe in accordance with ASTM F 794, and ASTM F 949, with the exception that pipe manufactured under ASTM F 949 shall have a minimum pipe stiffness of 46 psi.

720.11 Polyvinyl Chloride Closed Profile Wall Pipe. This specification covers polyvinyl chloride (PVC) closed profile wall smooth flow sewer pipe and fittings with integral bell joints. The inside diameters range from 4 through 48 inches. The pipe and fittings shall conform to ASTM F 1803.

720.12 Corrugated Polyethylene Smooth Lined Pipe. This specification consists of requirements for smooth lined corrugated polyethylene pipe, closed profile polyethylene pipe, couplings, and fittings conforming to AASHTO M 252 or AASHTO M 294, Type S, SP, or D, with the following modifications to AASHTO M 294:

1.1.1 Include nominal size of 4 to 60 inches.

4.1.2 Provide annular corrugated pipe (Type S or SP) or closed profile pipe (Type D).

6.1 The Contractor may blend carbon black with the virgin resin by means of a carrier resin. Provide the proportioning of the carrier resin to the carbon black no greater than 3:1.

7.2.1 Use nominal diameters of 4, 6, 8, 10, 12, 15, 18, 24, 30, 36, 42, 48, 54, and 60 inches.

7.2.2 Provide the inner liner of Type S and SP pipe, and both inner and outer walls of Type D pipe having the following minimum thicknesses, when measured in accordance with Section 7.2.2.

Diameter (in)	Inner Wall Thickness (in)
4	0.020
6	0.020
8	0.025
10	0.025
12	0.035
15	0.040
18	0.050
24	0.060
30	0.060
36	0.065
42	0.070
48	0.070
54	0.070
60	0.070

7.4 Provide pipe with a minimum pipe stiffness at 5 percent deflection, when tested in accordance with Section 9.1, as follows:

Diameter (in)	Pipe Stiffness (P/I/I)
4	50
6	50
8	50
10	50
12	50
15	42
18	40
24	34
30	28
36	22
42	20
48	18
54	16
60	14

7.8.5 In addition, provide "silt tight" bell and spigot or bell-bell couplings, or clamp-on bands for corrugated pipe for all sizes up to and including 36-inch diameter.

Provide "silt tight" bell-bell or bell and spigot couplings for Type D pipe. The Contractor may weld the coupling on one end of each length of pipe by means of a full circumferential weld. The Engineer will not allow stitch welds.

Use bell-bell or bell and spigot couplings for pipe diameters 42 inches and larger.

9.1 Select test specimens with the greater of a minimum length of 12 inches or one pipe diameter.

11.1.3 In addition, the Contractor may mark pipe with diameters 4 through 10 inches inclusive as "AASHTO M252".

12.1 Only provide materials from manufacturers on the City's pre-approved list.

720.13 Polypropylene Corrugated Double Wall Pipe. Provide polypropylene corrugated double wall pipe for non-pressure sanitary sewer and storm sewer pipe from 6 to 30-inch diameters in accordance with ASTM F 2736, and storm sewer pipe from 36 to 60-inch diameters according to ASTM F2881 or AASHTO M 330, with the following modification.

9.1 Provide a letter of certification to cover each shipment of material verifying that it meets specification requirements.

720.14 Polypropylene Triple Wall Pipe. Provide polypropylene triple wall pipe and fittings for non-pressure sanitary sewer and storm sewer pipe from 30 to 60-inch diameters in accordance with ASTM F 2764, with the following modification.

10.1 Provide a letter of certification to cover each shipment of material verifying that it meets specification requirements.

720.15 Glass-Fiber-Reinforced Polymer Mortar Pipe. Provide glass-fiber-reinforced polymer mortar pipe and fittings for non-pressure applications according to ASTM D 3262 and for pressure applications according to ASTM D 3754 with the following modifications:

4.1 Provide a minimum pipe stiffness of 36 psi.

7.2 Furnish certified test data as defined in 101.03 to the Engineer.

720.16 Polyvinyl Chloride (PVC) Pipe. Furnish PVC pipe conforming to AWWA C 900 or AWWA C 905. Furnish push-on type pipe joints conforming to ASTM D 3139 with a thickened bell and with a rubber gasket conforming to ASTM F 477.

ITEM 721 RAISED PAVEMENT MARKER MATERIALS

721.01 Raised Pavement Marker Castings.
721.02 Prismatic Retroreflector and Adhesive.
721.03 Casting Adhesive.

721.01 Raised Pavement Marker Castings. Provide nodular iron castings in accordance with ASTM A 536, hardened to 51-55 RC, snow plowable in the two opposing longitudinal directions and designed to accommodate a replacement prismatic retroreflector.

Provide materials in accordance with the City's Qualified Products List (QPL).

721.02 Prismatic Retroreflector and Adhesive. Provide reflectors containing one or two prismatic reflective faces to reflect incident light from a single or opposite directions. Provide reflectors with nominal dimensions of 4 × 2 × 0.48 inch. Fit the reflector securely in the recessed area and not protruding above the profile of the casting.

Provide manufacturer recommended retroreflector adhesive to bond the prismatic retroreflectors to casting.

Provide materials in accordance with the City's QPL.

721.03 Casting Adhesive. Casting adhesives will follow the acceptance procedure described below. The acceptance procedure will include materials testing and a flow test.

A. Provide adhesive material conforming to AASHTO M 237, Type IV, except having a viscosity of 200 to 900 poise at 77 + 2 °F), the unit weight of 11.3 to 11.9 pounds per gallon), and the air requirement is waived.

B. For materials conforming to the above requirements, provide samples of the adhesives to the City for flow testing.

The flow test procedure is:

1. In a standard 2 × 4 block of pine wood (3.5 in wide × 1.5 in deep × 22 in long) cut a channel in the block that is 3/4 in wide by 1/2 in deep with a dado blade. The channel will run longitudinally 22 inches long in the center of the 3.5 inch wide face of the wood block. Use tape to block off the ends of the channel.

2. Condition epoxy (Part A and Part B) and the wood block for a minimum of 4 hours at 120 °F.

3. Mix Part A and Part B epoxy separately for 15 seconds.

4. Mix Part A epoxy with Part B epoxy, at the manufacturer's required ratio, for 1.5 minutes. The total amount of sample mixed will equal 40 mL.

5. Temporarily dam off 6.5 inches of the channel at one end of the wood block.

6. Keeping the wood block flat, pour mixed product into the blocked off end of the channel for 30 seconds. The product should fill this blocked off volume. Remove the temporary dam.

7. Immediately place wood block with the epoxy filled channel on a 15 percent grade incline, with epoxy placed at the top of the slope.

8. Record distance the epoxy flows down the incline.

9. The average distance of three tests will be less than 20 inches.

Only furnish materials listed on the City's QPL.

ITEM 725 TRAFFIC SIGNAL UNDERGROUND

725.01 General.
725.02 Wire and Cable.
725.04 Rigid Galvanized Steel Conduit and Fittings.
725.051 Schedule 40 Polyvinyl Chloride Conduits and Fittings.
725.052 Polyethylene Conduits and Fittings.
725.053 Schedule 80 Polyvinyl Chloride Conduits and Fittings.
725.06 Polymer Concrete Pull Boxes.
725.08 Portland Concrete Pull Boxes.
725.10 Junction Boxes.
725.11 Luminaires.
725.12 Polyethylene, Fiberglass Reinforced, Pull Box with Polymer Concrete Cover and Support Ring.
725.15 Circuit Cable Connections and Terminations.
725.16 Ground Rods.
725.20 Multiple Cell Polyvinyl Chloride Conduit and Fittings.
725.21 Luminaire Supports.
725.22 Plastic Caution Tape.

725.01 General. Provide luminaires, conduits, wire, switch gear and other electrical hardware listed with Underwriters Laboratories.

Provide each item of manufactured electrical apparatus as a unit with a durable nameplate identifying the manufacturer and manufacturer's product identification.

The Engineer will inspect all lighting materials at the project site.

Only provide samples when required by the Laboratory.

725.02 Wire and Cable. Use nonshielded wire or cable rated 0-2kV with single conductor, stranded copper with cross-linked thermosetting polyethylene insulation, nonjacketed, meeting the requirements of ICEA S-95-658/NEMA WC70 and conforming to UL Type RHH-RHW-USE. Also use conductors 10 AWG and smaller with insulation meeting the requirements of UL Type XHHW.

Provide each non-shielded wire or cable rated 5000 volts (2400 volts)as a single conductor, stranded copper with chemically cross-linked polyethylene insulation, nonjacketed, meeting the requirements of ICEA S-96-659/NEMA WC71 and of UL Type MV-90 dry.

Provide each cable with an identification device defining its use with either a tag tied onto the cable or a band applied around the cable. Provide cable tags of copper, brass or plastic (except use nonconducting tags within switch and device cabinets) with 1/32 inch minimum thickness permanently fastened to the cables by means of cable tying straps. Provide cable identifying bands of approximately 1/32-inch thickness and wrap completely around the cable and close securely. Mark each tag or band using 1/4 inch minimum height embossed or engraved letters.

Mark conductors as “CKT” followed by the circuit designation shown on the plans; mark grounding conductors as “GND”; mark neutral conductors as “NEU”; and mark hot conductors as “Line” followed by “1” or “2” for single phase power or “Phase” followed by “A” or “B” or “C” for three phase power.

Provide materials in accordance with the City’s QPL.

725.04 Rigid Galvanized Steel Conduit and Fittings. Provide rigid galvanized steel conduit complying with the requirements of ANSI C 80.1 and UL 6 Type I and that each length of conduit bears the UL label. Provide fittings that comply with the requirements of ANSI/NEMA FB 1 and ANSI/UL 514B.

Provide materials in accordance with the City’s QPL.

725.051 Schedule 40 Polyvinyl Chloride Conduits and Fittings. Provide polyvinyl chloride conduit EPC-40-PVC conforming with NEMA Standard TC 2 for normal above ground or below ground installation, either concrete encased or direct burial. Use fittings conforming to NEMA Standard TC-2 references.

Provide materials in accordance with the City’s QPL.

725.052 Polyethylene Conduits and Fittings. Provide polyethylene conduit EPEC-80-HDPE conforming to NEMA Standard TC 7 for below ground only, for installation, whether concrete encased or direct burial. Use fittings conforming to ASTM D3350.

Provide materials in accordance with the City’s QPL.

725.053 Schedule 80 Polyvinyl Chloride Conduits and Fittings. Provide polyvinyl chloride conduit EPC-80-PVC, conforming with NEMA Standard TC 2 for normal above ground or below ground installation, either concrete encased or direct burial. Use fittings conforming to NEMA Standard TC-2 references.

Provide materials in accordance with the City’s QPL.

725.06 Polymer Concrete Pull Boxes. Provide polymer concrete pull box and cover of aggregate bound with a polymer resin. Provide the body of the box as of one piece construction. Provide smooth surfaces of the box and cover and the cover with a molded slip resistant surface. Ensure that the cover is slip resistant and is labeled in clearly legible block letters 1 to 2 inches in height integral to the cover with the word “TRAFFIC”, “LIGHTING”, “ELECTRIC” or “COMM” to designate the circuit(s) contained. Provide a cover closely fitting the opening and secured by stainless steel bolts hex head and hardware with the threaded holes into which the cover bolts fasten of open bottom design. Provide a minimum box depth of 15 inches. Provide the box and cover rated for installation in concrete area, rated as heavy duty, and meeting the structural requirements of Society of Cable Telecommunications Engineers Tier 15.

Provide materials in accordance with the City’s QPL.

725.08 Portland Concrete Pull Boxes.

A. Pull Box. Provide Portland concrete pull boxes constructed of reinforced portland cement concrete. Provide a pull box assembly rated as medium to heavy duty and rated for installation in concrete walks with stainless steel hex head bolts fastening the cover to the frame. For pull precast boxes, provide pull boxes from City’s QPL. Provide pull box covers constructed in accordance with 725.08.B and as shown on the plans.

B. Pull Box Covers. Provide metal pull box covers that conform to the following requirements:

1. Provide 1/2-inch thick steel plate for the steel cover conforming to 711.01 with 1/2-inch minimum flange around the edge and galvanized to conform to 711.02. Display on the steel cover or on an attached brass or stainless steel plate (tag) clearly legible block letters 1 to 2 inches in height with the word “TRAFFIC”, “LIGHTING”, “ELECTRIC” or “COMM” to designate the circuit(s) contained in the box. Provide the word designating the use in raised letters either integral to the steel cover or integral to a brass or stainless steel plate 1/16 inch in thickness securely mechanically attached to the steel cover by three (3) rivets, one on each end and one in the middle.

Provide the frame for the pull box designed with cover bolt holes offset from the frame corner by a nominal 1-1/2”, allowing the bolt hole to remain free of debris at all times. Secure the pull box cover with a heavy duty, threaded 3/8” x 16 u-nut securely inserted into the frame bolt hole opening. Make the 1/8” x 1 1/4” frame (20” sq. OD) and cover (19 3/4” sq. OD) from A36 steel, galvanized after fabrication conforming to A123. Provide the cover with a 3/4” pick hole on the cover centerline and 4” from the edge. The City will not require countersunk cover bolt holes. Provide the pull boxes with knockouts (4 each) on a 12”x12” area starting at the pull box bottom and centered in the sidewall.

2. Provide gray iron or ductile iron with a minimum thickness of 3/8 inch conforming to 711.14. The Engineer will require certification. Provide the word “TRAFFIC,” “LIGHTING”, “ELECTRIC,” or “COMM” cast in the top surface of the cover forming letters 1 to 2 inches in height.

725.10 Junction Boxes. Provide junction boxes of iron castings hot-dip galvanized in accordance with 711.02. Ensure that the junction boxes meet the requirements of NEMA ICS-6-Type 3. When the City specifies a drilled and tapped conduit entry, provide the junction box with adequate wall thickness and a boss cast into the box, if necessary.

Provide materials in accordance with the City’s QPL.

725.11 Luminaires.

A. Optical System. Provide a luminaire set to the photometric distribution stipulated in the plan indicating the distribution along with the settings required to produce it. Place on a durable label affixed to the interior of the housing in a position readily apparent and easily read by a worker lamping the luminaire.

Provide a luminaire with a borosilicate glass refractor free of striations and imperfections and embossed to clearly indicate the street side for refractors that the Contractor could install in more than one position. Firmly hold the refractor in the housing, but allow for easy removal without the use of special tools.

Provide a luminaire with an aluminum reflector with a specular polished reflective surface free from scratches. Firmly hold the reflector in the housing, but allow for easy removal without the use of special tools.

Provide a luminaire with a socket for mogul base lamps for applications allowing a choice of size.

Provide a lamp socket with a large center contact spring providing a firm contact with the lamp base and lamp grips to prevent the lamp from loosening. Shroud the shell in porcelain and identify the wiring terminals and contacts.

Provide the socket position adjustments with positive indexing such as holes, lugs, or notches. Do not provide lamp sockets with infinite settings.

Do not use socket adaptors.

B. Lamps. Provide a luminaire with a lamp of the type and wattage specified. Provide each lamp with a clear glass envelope, a date recording feature, and no ballasting or starting components.

Provide first line, high quality high pressure sodium lamps having heat resistant clear glass envelopes with a quartz arc tube interior with horizontal initial lumens. Provide high pressure sodium lamps with approximate hours of life not less than the values shown in Table 725.11-1.

TABLE 725.11-1

ANSI	WATTS	Horizontal Lumens Initial	Economic Life Hours
S62	70	5,800	14,000
S54	100	9,500	14,000
S55	150	16,000	16,000
S66	200	22,000	16,000
S50	250	27,500	16,000
S67	310	37,000	16,000
S51	400	50,000	16,000
S52	1,000	130,000	16,000

Provide high pressure sodium lamps that produce a minimum of 80 percent of the initial lumen output at the end of economic life.

Provide materials in accordance with the City's QPL.

C. Ballast. Provide a ballast of an integral design contained within the luminaire housing.

Provide a ballast (in conjunction with the starter in the case of high pressure sodium lamps) capable of starting and operating the lamp at ambient temperatures as low as -20 °F.

At circuit voltage of nominal plus or minus 10 percent or the ballast manufacturer's stated range if greater, ensure that the ballast can start (in conjunction with the starter in the case of high pressure sodium lamps) and operate the lamp within the lamp's ANSI operating parameters for the full design life of the lamp.

Provide a ballast capable of operation with the lamp in an open or short circuit condition for six months without significant loss of ballast life.

Provide a starter of encapsulated solid state design capable of withstanding the temperatures encountered in the ballast compartment of the luminaire.

Provide the starter with a timed pulsing with sufficient follow through current to completely ionize and start all lamps meeting published ANSI standards.

Provide a starter with push-on type electrical terminations, field replaceable with no adjustment necessary for proper operation.

Provide a barrier type terminal block for connection of the incoming electrical circuit.

D. Housing. Provide a housing of cast aluminum.

Provide the housing with a flat area on the top side to place a level may be placed readable by a worker leveling a mounted luminaire on an erected support.

Provide the door(s) providing access to the optical and electrical components with hinges and latches of corrosion resistant materials that remain securely closed during operation.

Provide silicone rubber, ethylene propylene terpolymer, dacron felt or other durable gaskets and seals supplied by the manufacturer either as part of the basic luminaire or as options in good condition and properly installed at the socket entry, between the refractor and reflector, and any other location where such gaskets or shields make up a part of the luminaire and options.

Provide the exterior finish of the luminaire with a light gray color unless otherwise specified.

Provide a glare shield of aluminum or opaque plastic material when specified. Provide a shield supplied by the manufacturer of the luminaire.

E. Conventional Luminaries. Provide luminaire housing doors capable of opening, closing, removal, or installation without the use of tools.

Provide the clamp for the slip-fit mounting accommodating both 1 1/4 inch and 2 inch nominal pipe mounting brackets. Provide a stop as part of the housing to prevent over insertion of the bracket into the housing. Design the clamp to engage at least 4 1/2 inches longitudinally along the arm of the bracket arm between the extremes of a minimum of two clamping points. Design the mounting clamp to provide for leveling of the luminaire to the specified transverse and longitudinal positions with respect to the roadway.

Equip the luminaire with a device indicating the direction and amount of tilt over a range of zero to five degrees in any direction with indications at level, three degree tilt and five degree tilt all accurate to one half degree. Provide an indicating device clearly readable in daylight from a distance of 50 feet and does not alter or reduce the amount of light from the luminaire. Construct the indicating device of a transparent container having one horizontal surface curvilinear in any vertical cross section for supporting an indicator and a damping fluid. Provide a damping fluid of a liquid suitable for operation at -40° F and fabricate the transparent container from clear ultraviolet-inhibited acrylic or similar material.

Provide a glare shield cutting off the upward component of light to not reduce the total output of the luminaire more than 3 percent.

Provide the luminaire with a label or decal indicating the type of source and wattage rating. Provide the luminaire installed in its normal operating position with a label or decal clearly legible in daylight at a distance of 50 feet. Provide the labeling in accordance with the provisions of NEMA Publication OD-150 or EEI Publication TDJ-150.

Provide the complete conventional luminaire assembly including the lamp and all options including, if required, with the glare shield weighing not more than 75 pounds.

Provide materials in accordance with the City's QPL.

F. Wall Mounted Underpass Luminaires. Provide a weatherproof assembly sealed against dust.

Provide a wire entry for the incoming power on both of the vertical side surfaces of the housing, drilled and tapped for 3/4 inch conduit, with the unused entry properly closed with the screw type plug supplied by the manufacturer.

Provide luminaire housing doors capable of be opening, closing, removal, or installation without the use of special tools.

Provide housing mountable on a vertical flat surface by means of cap screws or bolts through the wall side of the housing.

For mounting on concrete, use adhesive-grip anchors designed to be set into a drilled hole half-filled with material meeting 705.20, with a minimum hole depth of 1-3/4 inches.

Ensure that the luminaire has the option for protecting the glass refractor with a guard or shield integral to the luminaire and not requiring removal for access to the lamp or ballast.

Provide materials in accordance with the City's QPL.

G. High Mast / Low Mast Luminaires. Provide luminaires with a symmetric distribution having an initial intensity of no more than 100 candela per 1000 lamp lumens at nadir and no more than 325 candela per 1000 lamp lumens at angles between 55 and 65 degrees above nadir.

Provide luminaires with an asymmetric distribution or a long and narrow distribution having an initial intensity of no more than 175 candela per 1000 lamp lumens at nadir and no more than 425 candela per 1000 lamp lumens at angles from 66 through 73 degrees above nadir.

Provide a luminaire with an output efficiency of not less than 65 percent of the bare lamp lumens. Provide a luminaire that emits at least 25 percent, but not more than 35 percent, of the bare lamp lumens at vertical angles between at least 60 degrees above nadir and not more than 90 degrees above nadir.

Provide a luminaire with no portion of the arc tube of the lamp viewable at angles of 70 degrees or more above nadir.

Provide for the photometric distribution produced by an optical assembly consisting of a reflector alone or in combination with a refractor and redirected to the output of a lamp mounted in a socket. Provide a one piece design for the reflector and refractor (if used).

Provide a field rotatable optical assembly to align the light distribution horizontally independent of the orientation of the arm supporting the luminaire.

Provide a luminaire for use with a 1000 watt lamp having an auxiliary lamp support engaging the outer end of the lamp envelope.

Provide a luminaire of substantial design adequate to operate at mounting heights up to and including 150-feet and wind velocities up to and including 90 mph.

Provide a luminaire that mounts by means of a slip fit onto a horizontal 2 inch pipe. Provide for the luminaire's integral mounting by providing adjustment for leveling while remaining secure and not twist about the mounting pipe of the bracket when subjected to the vibration and wind loads of the installation.

Provide a complete luminaire with a maximum weight not exceeding 75 pounds and a maximum projected area not exceed 3.5 square feet.

Provide materials in accordance with the City's QPL.

725.12 Polyethylene, Fiberglass Reinforced, Pull Box with Polymer Concrete Cover and Support Ring. Provide a pull box body made of fiberglass reinforced high density ultraviolet stabilized molded polyethylene with a polymer concrete cover support ring and polymer concrete cover. Provide a body consisting of one piece construction with a wall thickness of at least 1/4 inch. Use a cover support ring permanently integrated into the box and a slip resistant cover having in clearly legible block letters 1 to 2 inches in height integral to the cover the word "TRAFFIC", "LIGHTING", "ELECTRIC" or "COMM" to designate the circuit(s) contained. Provide a cover closely fitting the opening and

secured by stainless steel bolts and hardware with threaded holes of open bottom design for the cover bolts to fasten to. Ensure that the box and cover meet the structural requirements of Society of Cable Telecommunications Engineers Tier 5.

Provide materials in accordance with the City's QPL.

725.15 Circuit Cable Connections and Terminations. Ensure that each connector or terminator is of the same voltage rating as the wire being connected or terminated except that 600 volt connectors may be used with 5000 volt (secondary service) cable used in 600 volt service for the highway lighting circuits.

Use compression style connectors or terminators that fully enclose the conductor(s) made of high strength copper alloy and not a plated metal other than copper. Use sleeve type connectors for "butt" splices with a "stop" in the center.

A. Termination of Oversize Wire. Use a cable terminal for each device capable of properly accommodating the size of the terminated wire. If the Contractor cannot provide a terminal of adequate size, use a short length of smaller wire connected to the oversize conductor with a proper butt style crimp connector or a terminal block. Do not cut back strands in the oversize conductor to make the connection and use a smaller wire rated to carry the full ampacity of the circuit protection device.

B. Fused Pull-Apart Connection. Provide each fused pull-apart cable connector kit in a molded synthetic rubber housing consisting of a female line side with two ports and a male load side with one port containing a socket type fuse holder allowing the fuse to act as the pin for the load connection designed to break the circuit upon separation of the two halves of the connector body. Use an assembled kit rated for direct burial and exposure to sunlight. Use copper metal connector parts with a conductivity of 90 percent, having individual compression connections for each wire on the line side, having a crimp connection for the wire on the load side, and having annular spring on the socket for each end of the fuse. Use a fuse holder for a standard midget 13/32 × 1 -1/2-inch fuse rated 600 VAC, 100,000 AIC, and not having a glass body. Use a cable port sized for the wire or cable entering the port and a closure for the second line port if not used.

C. Unfused Pull-Apart Connection. Provide each unfused pull-apart cable connector kit in a molded synthetic rubber housing consisting of a female line side with two ports and a male load side with one port containing a line side socket and load side pin making a connection designed to break the circuit upon separation of the two halves of the connector body. Use an assembled kit rated for direct burial and exposure to sunlight. Use copper metal connector parts with a conductivity of 90 percent, having an individual compression connection for each wire on the line side, having a crimp connection for the wire on the load side, and having an annular spring on the socket for the pin. Use a cable port sized for the wire or cable entering the port and a closure for the second line port if not used.

D. Unfused Bolted Connection. Provide each unfused re-enterable cable connector kit in a rigid molded plastic sleeve closed on each end by a molded synthetic rubber female end housing having one or two ports as needed containing space to make the connection by crimping a lug onto each wire and then bolting all of the lugs together. Use an assembled kit rated for direct burial and exposure to sunlight. Use copper metal connector parts with a conductivity of 90 percent and connecting bolts having self-locking nuts. Provide ports sized for the wire entering each port and a closure for a port if not used.

E. Unfused Permanent Connection. Provide each cable splicing kit in a rigid transparent molded body having as many as two ports on each that allows a completely encapsulated completed splice by filling the mold with a resin compound. Provide the actual conductor connections made using one time use compression connectors with each wire or cable entering the mold through its own port.

Provide materials in accordance with the City's QPL.

725.16 Ground Rods. Provide ground rods 1 inch in diameter and 10 feet in length with a driving point on the lower end. For other cross sections, provide rods with a periphery at least 3.2 inches. Ensure that the rod is of solid construction and is either stainless steel jacketed steel or copper clad steel, or hot dipped galvanized steel in accordance with ASTM A 153, Class B-1 and UL Listed.

For traffic signal installations, use cross-linked polyethylene ground wire cable with a minimum #6 awg copper, stranded, RHW insulated, 600 volt rated and exothermically welded to the ground rod with insulating varnish applied to the weld. Use copper in the ground wire hard enough to withstand the exothermal welding process but soft enough to melt and form a solid bond to the rod.

Provide UL listed rods with labels showing same.

Provide materials in accordance with the City's QPL.

725.20 Multiple Cell Polyvinyl Chloride Conduit and Fittings. Provide multiple cell conduit consisting of inner ducts conforming to NEMA TC-8 type DB in an outer conduit conforming to NEMA TC-2 (type EPC-40 or EPC-80 as specified, except measure size by the true inside diameter) in a factory preassembled unit. Provide factory made coupling fittings that couple inner ducts and the outer conduit simultaneously, maintain the continuity and indexing of the inner ducts and consist of a push fit design mechanically locked in place.

Provide materials in accordance with the City's QPL.

725.21 Luminaire Supports. Provide a complete luminaire support from the luminaire(s) down through the connection to the foundation or other structure conforms to the requirements of AASHTO's "*Standard Specifications for Structural Supports for Highway Signs, Luminaires and Traffic Signals*". Ensure a combined stress ratio above the first field joint greater than the combined stress ratio at the base of the pole.

Use a design wind speed for all areas of the State of 90 mph.

The Engineer may require various tests including destructive tests at either the factory or on site prior to acceptance of a support, supervised by the City's representative and performed by the Contractor and/or manufacturer as appropriate on supports selected at random by the City of Columbus from the lot produced for the project. Replace any support damaged by the testing at no additional cost to the City.

Provide adhesive support identification labels with silver white reflective characters on a reflective green background meeting the requirements of 730.18.

Provide certified luminaire supports in accordance with ODOT Supplement 1091.

A. Light Poles. Provide poles with a maximum deflection of the pole from vertical when placed under the load of the bracket arm, and a weight of 55 pounds in place of each luminaire of 1 degree 40 minutes when tested in accordance with ODOT Supplement 1025. Submit certified copies of the results from the deflection tests to the Laboratory.

The Contractor may provide a pole and arm constructed from either aluminum or steel. Do not provide a combination of aluminum and steel.

Provide bracket arms made from straight or tapered stock round or ovaliptic in cross section not less in size than 2 inch nominal pipe.

Provide the luminaire end of each bracket arm having an outside diameter equal to 2 inch pipe, straight for a distance of eight inches, with the longitudinal axis canted not less than 1 degree and not more than 4 degrees above horizontal.

Provide a bracket having an internal raceway with a minimum internal diameter of 1-3/32 inches free of projections and obstructions, permitting, after assembly, installation of luminaire supply conductors without insulation damage and not requiring bending the conductors to a radius less than 3 inches.

Provide a pole with no more than two sections, with the shorter section of a sectional at the top and the shorter section of a sectional pole not less than 10 feet in length. Join the pole sections by telescoping the bottom of the upper section over the top of the lower section for a minimum length of 1 1/2 times the external diameter of the bottom of the upper section, driving the joint tight, and securing by through bolting with a stainless steel hex head bolt of a minimum diameter of 5/8 inch.

Provide poles with a pole section having no more than one longitudinal, automatically electrically welded seam and no transverse seams looking neat and uniform in appearance, with the weld not less than the thickness of the base material and the bead height not exceeding 1/16 inch. Provide a uniform wall thickness throughout, except at the weld bead. Provide a circular pole cross section, or multi-sided pole cross section with no less than eight sides with the difference between the major and minor diameters of poles of circular cross section or the difference between the maximum and minimum distances across corners for poles of multi-sided cross section, measured at any point along the longitudinal axis, not exceeding 3/16 inch.

Use steel poles consisting of tapered tubes with a true continuous taper not less than 0.06 inches per foot and not more than 0.16 inches per foot.

Use aluminum poles, either spun or cold rolled, with a true continuous taper except for straight top and bottom sections. Provide poles with no more than 40 percent of the total shaft length straight, and with the average rate of shaft taper including straight portions of the shaft not less than 0.06 inches per foot and not more than 0.16 inches per foot.

Provide poles capable of transmitting the full design strength of the pole shaft section in bending through the base plate into the transformer base or the anchor bolts without permanent bending of the base plate or failure of the pole shaft to base plate connection.

Provide a “J” hook inside the pole just below the top to hang the pole and bracket cable support assembly.

Provide nonstructural castings for aluminum poles, including the pole cap conforming to ASTM B 26/B 26M or B 108, Alloy S 5 A, Condition F.

Provide steel poles and bracket arms hot dipped galvanized after fabrication in accordance with the requirements of 711.02.

Provide aluminum poles and bracket arms in natural aluminum with a satin brushed surface.

Identify each light pole by a raised or engraved marking applied to the edge of the base plate that identifies the manufacturer and the year of manufacture, capable of remaining legible after galvanizing the pole.

Use bolts, nuts, washers, and other fasteners to assemble the light pole of galvanized steel conforming to 711.02, stainless steel conforming to ASTM A 320 (AISI-300 series), or silicon bronze conforming to ASTM B 98M (B 98).

Provide non-frangible steel transformer bases capable of transmitting the design dead, live, ice and wind loads of the light poles mounted on the bases to the foundations without failure or permanent deformation. Provide bases with a flush door permanently attached by means of a top-mounted continuous stainless steel hinge, and made from steel conforming to ASTM A36 hot dip galvanized after fabrication.

Provide frangible aluminum transformer bases capable of transmitting the design dead, live, ice and wind loads of the light poles mounted on the bases to the foundation without failure or permanent deformation. Provide bases with a flush aluminum door, bolted, or (if specified) permanently attached by means of a top-mounted continuous stainless steel hinge, bearing easily found, and read-durable labeling meeting AASHTO frangibility criteria. Provide bases tested and accepted by the FHWA as complying with the 1985 AASHTO frangibility requirements

Use heavy hex bolts and nuts to fasten the base plate of the pole to the transformer base conforming to ASTM A 307 and galvanized in accordance with 711.02. For the tops or the bottoms of aluminum transformer bases fastened against non-galvanized steel, provide the steel and the aluminum mating surfaces with a coating of heavy film of zinc rich paint.

Use anchor bolts that are ASTM F1554 steel with 55,000 psi minimum yield strength, are galvanized in accordance with 711.02 and that have nuts capable of developing the full strength of the anchor bolt and are galvanized in accordance with 711.02.

B. Light Towers. Provide light towers with a structural design based the greater of either a load of six luminaires or the actual number of luminaires installed. Provide light towers with a structural design based on the greater of either each luminaire weighing 75 pounds and having an

effective projected area of 3.5 square feet or the actual weight and effective projected area of each luminaire. Provide light towers with a structural design based on the greater of either the head frame assembly with lowering device weighing 340 pounds and having a projected area of 5.3 square feet or the actual weight and effective projected area of the head frame and lowering device.

Provide a luminaire lowering device (consisting of the luminaire ring, the head frame, the winch, the power cables and all miscellaneous mechanical and electrical equipment mounted in or on the pole) compatible with the pole.

1. Luminaire Ring. Provide a luminaire ring assembly fabricated from steel that conforms to ASTM A 36 and with a ring fitted with a separate 2 inch nominal steel pipe mounting arm directly attached to the ring for each luminaire.

Provide the luminaire ring with support by three wire ropes equally spaced around the ring. Provide wire ropes of the same material and construction having a 3/16 inch minimum diameter of either galvanized steel hoisting cable or aircraft grade stainless steel control cable made with 7 strands of 19 wires each. Connect each wire rope support cable to the ring by a corrosion resistant device allowing the connection to develop the full breaking strength of the wire rope while permitting ready adjustment of the length of the wire rope to level the ring. Equip the ring with a minimum of three spring loaded roller tipped centering arms equally spaced around the ring in continuous contact with the pole shaft, having guide arm rollers with nonabrasive, water resistant material.

Equip the luminaire ring with three positive latching devices equally spaced around the ring that latch to the head frame supporting the ring in the raised position allowing removal of tension to be removed from the lifting cables. Make all moving parts of each latching device part of the ring portion of the latch assembly with each latch assembly incorporating a reflectorized flag clearly discernible from the ground with the ring latched to the head frame. Do not allow the latching sequence to exert a horizontal force in excess of 4 g's acceleration upon the luminaires.

Equip the luminaire ring with a NEMA 4 corrosion resistant junction box for the connections between the main power cord bringing power to the ring and the separate power cords for each luminaire. Conform to Article 409 of the NEC for construction of the junction box. Use copper conductors of adequate size and insulation for each power cord, suitable construction for each power cord, and power cords entering the junction box through a weather tight cord connector. Use a cord support capable of withstanding a load of 1-1/2 times the weight of the main power cord without damage to the cord transmitting the weight of the main power cord directly to the ring. Provide a weather tight power inlet on the luminaire ring allowing the main power cord in the base of the tower to connect to the ring when in the lowered position. Equip the junction box with a 600 volt class terminal block for the connections between the main power cord, the luminaire power cords, and the power inlet cord. Identify each luminaire ring by a raised or engraved marking applied in a prominent location identifying the manufacturer and the year of manufacture, legible after the ring galvanizing.

2. Head Frame Assembly. Fabricate the head frame from steel conforming to the requirements of ASTM A 36. Equip the head frame assembly with pulleys for the wire ropes hoisting cables and rollers for the main power cord to the luminaire ring. Provide hoisting cable sheaves with a tread diameter of at least 20 times the cable diameter for galvanized cable and 25 times the cable diameter for stainless steel cable, with the groove for the hoisting cable having a semi-circular cross section with a radius of one-half the cable diameter plus 1/64 inch, with the sheave having an oil-impregnated bronze bushing, and with the shaft supporting the sheave made of stainless steel. Provide rollers for power cord run on AISI 304 stainless steel shafts between cold-rolled steel plates. Provide a power cord with a bending radius not less than 7 inches. Install keeper bars over the power cord and ring support cables to keep them in their respective tracks. Provide a guide to separate the individual cables as they pass between the head frame and the top of the pole. Protect the head frame mechanism from the weather by a domed cover of either copper, free spun aluminum, or fiberglass. Identify each head frame by a raised or engraved marking applied in a prominent location showing the manufacturer and the year of manufacture, legible after galvanizing the head frame.

3. Transition Plate. Provide a transition plate between the ring support cables and the main hoisting cable. Secure the luminaire ring support cables to the transition plate by shop applied, swage-type fittings designed to develop a connection strength equal to the breaking strength of the cable and prevent abrasion of the cable by the transition plate. Provide a cord support capable of withstanding a load of the weight of the main power cord plus a wind load on the cord equal to a 30 mph wind perpendicular to the full length of the cord without damage to the cord connecting the main power cord to the transition plate.

4. Hoisting Winch. Provide a winch of cast iron and steel construction with an integral enclosed lubricant bathed worm and gear drive having a reduction great enough for self-locking. Provide the winch with a pulling capacity at least five times greater than required to lift the load. Provide the winch drum with a diameter not less than 4 inches, and the drum flange with a diameter at least 3 inches greater than the diameter of the drum. Prevent cable buildup at the ends of the winch drum with a cable guide or follower. Provide the support plate for the winch with a durable tag identifying the manufacturer, manufacturer's model, and year of manufacture for the lowering device.

5. Winch Drive Unit (Portable Power Unit). Power the winch drive unit by a heavy duty reversing drill motor with a minimum 560 W rating, 120 volt. Provide a mechanical slip clutch torque limiter incorporated into the output shaft with a placard on the portable winch drive unit giving the settings and instructions for care of the torque limiter. Include a separately packaged dry type isolated winding transformer to permit operation of the drill motor from the lighting circuit by plugging into the luminaire power cord outlet in the base of the tower. Provide a cord outlet and plug for connecting the motor to the transformer complying with NEMA L5-15. Ensure a hoisting rate of between 15 and 25 feet per minute. Provide a hand control switch incorporating 20 feet of cable to allow operation of the lowering device from a position away from the pole and not beneath the ring and luminaires. Provide each winch drive unit frame with a raised or engraved marking applied in a prominent location identifying the manufacturer and the year of manufacture, legible after application of final finish to the frame.

6. Connection of Tower to Lighting Circuit. Provide a separate terminal block for each conductor of the supply circuit in the base of the tower, and enough spaces on the blocks to allow the incoming circuit to split into three outgoing directions in addition to the feed to the tower itself. Provide the terminal block with set screw style terminations, sized for 4 AWG - 1/0 AWG for the incoming and outgoing lighting circuit, and 12 AWG - 10 AWG for the tower wiring. Provide a circuit breaker in a NEMA 3R, 4, or 4X enclosure located electrically after the terminal blocks for the lighting circuit and before the power cord leading up the tower to the luminaires. Internally mount the breaker enclosure and make

the breaker readily accessible through the tower hand hole. Provide a bolt-on design for the circuit breaker, sized at 15 amperes with a minimum interrupting capacity of 14,000 amperes for 480 volt circuits or sized at 20 amperes with a minimum interrupting capacity of 10,000 amperes for 240 volt circuits and having a single handle rather than a tied handle design with one pole for each line or phase conductor. Ensure that each breaker pole has one or more mechanical lugs, one per wire. Ensure that complete lug shields are installed on the breaker. Provide a cord connector, plug, and inlet on the ring for electrical power to the luminaires conforming to NEMA L8-20 for 480 volt systems or to NEMA L6-30 for 240 volt systems.

7. Operating Manual. Provide a complete manual including instructions on installation, operation and maintenance for each type of the following: lowering device, winch assembly and portable power winch drive unit.

8. Shaft. Provide a tower shaft with not more than four round or multi-sided tapered steel sections for towers up to and including 100 feet, five sections for towers over 100 feet up to and including 120 feet, and six sections for towers over 120 feet. Use steel for the shaft having a minimum yield strength of 55,000 psi. Join the shaft sections by telescoping the bottom of the upper section over the top of the lower section for the greater of either a minimum length of 1 1/2 times the external diameter of the bottom of the upper section or two feet and driving the joint tight. Pre-fit the sections and match-mark at the factory. Provide a smooth inside surface of the shaft with no more than two longitudinal welds made by automatic electric arc welding. Make the longitudinal seam welds with complete penetration, having uniform density, no thinner than the shaft material and not more than 20 percent thicker than the shaft material. Fabricate the base plate from steel conforming to the requirements of ASTM A 36 and join the shaft to the base plate using the American Welding Society prequalified joint TC-U4a-S or TC-U4c-GF. Reinforce the hand hole in the shaft to avoid stress risers and weld the reinforcements to the shaft using a joint and techniques designed to ensure total penetration plus an outside fillet equal to the thickness of the shaft material. Provide welds in the shaft conforming to AWS D 1.1 Structural Welding Code Article 9.25.3 for tensile stress when tested either by the ultrasonic method or by an approved alternate method. Submit certified results to the Laboratory. Fabricate the door from the same type steel as the shaft, attach with a continuous stainless steel hinge having non-removable stainless steel hinge pins, fit closely to the door opening, and secure in the shut position. Provide for padlocking the handhole door closed and provide each tower with a vandal resistant padlock having a bronze or brass lock body and a corrosion-protected steel shackle keyed to the key number specified by the maintaining agency. Provide two holes, tapped 1/2-13, 180 degrees apart, at the base of the tower for the grounding conductors. Hot dip galvanize the shaft after fabrication in accordance with the requirements of 711.02. Provide identification on each shaft by a raised or engraved marking applied to the edge of the base plate showing the manufacturer and the year of manufacture, legible after galvanizing the pole.

9. Anchor Bolts and Nuts. Provide steel anchor bolts conforming to ASTM F1554, Grade 55, and galvanize in accordance with 711.02. Use nuts with each anchor bolt capable of developing the full strength of the anchor bolt.

725.22 Plastic Caution Tape. Provide tape from an inert material, approximately 6 inches wide composed of polyethylene plastic, highly resistant to alkalis, acids or other chemical components that the Contractor likely will encounter in soils. Provide bright red tape with identifying printing "ELECTRIC" in black letters on one side only. Provide bright orange tape with identifying printing "TRAFFIC" in black letters on one side only. Provide tape in continuous rolls with the identifying lettering repeated continuously the full length of the tape.

ITEM 726 BARRIER REFLECTOR MATERIALS

726.01 Barrier Reflectors.

726.01 Barrier Reflectors. Furnish concrete barrier, retaining wall, and bridge parapet reflector body housings that are made of acrylic or polycarbonate plastic, or corrosion resistant metal. Ensure that the minimum reflective surface area of the reflector is 7 square inches.

Furnish white reflectors that reflect the following minimum candela of light at the indicated observation angles for each 1 foot-candle of incident light at the indicated entrance angles. Furnish amber reflectors that reflect at least 60 percent of these values.

MINIMUM SPECIFIC INTENSITY, CD

	Observation Angle	
Entrance angle	**0.2°**	**2.0°**
-4°	62	0.25
15°	52	0.18

The entrance angle is measured in the horizontal plane between the direction of incident light and normal to the face of the reflector. The observation angle is measured in the vertical plane between the observer's line of sight and the direction of light incident to the reflector face.

Furnish guardrail blockout reflectors that are a minimum size of .5x10.0.125 inches and made of corrosion resistant metal with ¼" predrilled mounting holes. One or both sides shall be covered with a minimum 4.5x5 inches of Type G, H or J reflective sheeting.

Furnish materials in accordance with the City's QPL.

ITEM 730 TRAFFIC SIGN AND SUPPORT MATERIAL

730.01 Steel Tube and Pipe.
730.015 U-Channel Posts.
730.016 Square Posts.
730.017 Street Name Sign Supports
730.02 Steel Anchor Bolts and Nuts.

730.03 Steel Poles and Arms.
730.04 Base and Arm Plates.
730.05 Handhole Covers.
730.06 Pole Caps.
730.07 Arm Caps.
730.08 Steel Hardware.
730.09 Stainless Steel.
730.10 Stainless Steel Hardware.
730.11 Aluminum Sheet and Plate.
730.12 Aluminum Extrusions.
730.13 Aluminum Tube and Pipe.
730.14 Aluminum Castings.
730.15 Aluminum Forgings.
730.16 Aluminum Welding Rods.
730.17 Aluminum Hardware.
730.18 Reflective Sheeting Type F.
730.19 Reflective Sheeting Type G.
730.191 Reflective Sheeting Reboundable.
730.192 Reflective Sheeting Type H.
730.193 Reflective Sheeting Type J.
730.20 Nonreflective Acrylic Opaque Sheeting.
730.22 Silk Screen Inks.
730.23 Transparent Acrylic Electronic Cuttable Films.
730.24 Cantilever Offset Bracket.

730.01 Steel Tube and Pipe. Provide steel tube and pipe in accordance with ASTM A 53, Grade B, ASTM A 500 Grade B, or ASTM A 501, except provide tubing for truss and end frame diagonals in accordance with 711.01.

730.015 U-Channel Posts. Fabricate U-channel posts from steel into a characteristic cross section for use alone or paired to form a heavier post by bolting together back to back. Provide posts with a uniform cross section for their full length. Cut posts square to a length tolerance ±1 inch. Remove any ragged or sharp edges, or cracks or other imperfections affecting strength or durability. The Contractor may fabricate the posts with flat backs or with raised longitudinal ribs.

Provide posts meeting the deflection criteria of ODOT Supplement 1075. Provide posts manufactured from rail or billet steel in accordance with ASTM A 499, Grade 60.

Furnish posts with a nominal weight before punching or galvanizing as follows:

Post Size Number	Weight lb/ft	Tolerances %
1	1.12	-3.5, +10.0
2	2.00	-3.5, +10.0
3	3.00	-3.5, +10.0

Furnish posts with 3/8-inch diameter holes accurately punched on the centerline spaced at 1-inch centers beginning not more than 1 1/8 inches from the top of the post through the entire length, to allow bolting the posts back to back, without redrilling, using 5/16-inch diameter bolts. Furnish posts that have been galvanized after punching to 711.02.

Furnish materials in accordance with the City's QPL.

730.016 Square Posts. Provide square posts fabricated from steel in accordance with ASTM A 1011 with a minimum yield strength of 60,000 pounds per square inch, with 7/16-inch diameter die-cut knockouts or open holes spaced every 1-inch on the centerline of all four sides, in true alignment and opposite each other. Provide posts with the dimensional requirements conforming to ODOT's Standard Drawing TC - 41.20, Yielding Post. Provide posts finished with one of the following methods:

A. Apply hot-dip galvanizing to the inside and outside of the post in accordance with ASTM A 653 G-235.

B. Apply zinc coating to the outside of the post at a rate of 0.80 ounce per square foot followed by chromate conversion coating and a cross-linked polyurethane acrylic coating. Provide the inside of the post with a zinc organic coating.

Provide materials in accordance with the City's QPL.

730.017 Street Name Sign Supports. Provide street name sign posts fabricated from new hot-dipped galvanized steel pipe as in 711.02 and in accordance with ASTM Specification Number A53 with a minimum yield strength of 30,000 psi and a minimum tensile strength of 48,000 psi. Evidence of prior rusting or pitting shall be cause for rejection of the posts. The street name sign post shall have a tubular section of uniform diameter and wall thickness. The diameter and wall thickness shall be for the standard weight (Schedule 40) nominal pipe size (NPS) as specified for each bid item. The finished post shall be straight, have a smooth finish and be free from defects affecting their strength, durability or appearance. All cut ends shall be free from burrs. Each piece shall be continuous with no butt welds.

Provide materials in accordance with the City's QPL.

730.02 Steel Anchor Bolts and Nuts. Provide anchor bolts made of steel conforming to ASTM F1554 Grade 105, galvanized in accordance with 711.02 at least 2 inches beyond the threads, with the end either bent or with a drilled and tapped steel plate. Provide leveling nuts and anchor nuts capable of developing the full strength of the anchor bolt.

Provide materials in accordance with the City's QPL.

730.03 Steel Poles and Arms. Provide poles and arms made of steel with a minimum yield strength of 52,000 pounds per square inch and galvanized in accordance with 711.02.

Provide certified material in accordance with ODOT Supplement 1093.

730.04 Base and Arm Plates. Provide support or pole anchor bases and arm attachment plates fabricated from steel plate in accordance with ASTM A 36 or ASTM A 572, Grade 42. Weld plates to supports, poles, or arms both inside and outside with fillet or full penetration welds equal to the wall thickness, or by AWS prequalified welding joints TC U4a-S or TC U4c-GF. The Contractor may use a cast steel base of equivalent strength.

Provide certified material in accordance with ODOT Supplement 1093.

730.05 Handhole Covers. Provide handhole covers for poles and overhead sign supports made of 0.109-inch galvanized steel or 0.125-inch nominal aluminum alloy.

Provide certified material in accordance with ODOT Supplement 1093.

730.06 Pole Caps. Provide pole caps made of aluminum, galvanized ferrous metal, or zinc die casting.

Provide certified material in accordance with ODOT Supplement 1093.

730.07 Arm Caps. Provide arm caps made of steel that cover at least 50 percent of the end area.

Provide certified material in accordance with ODOT Supplement 1093.

730.08 Steel Hardware. Provide bolts 5/8-inch diameter or larger in accordance with ASTM A 325. Provide bolts and screws less than 5/8-inch diameter in accordance with SAE J429, Grade 5. Provide nuts of all size, except anchor nuts and leveling nuts, in accordance with SAE J995, Grade 2. Provide flat washers in accordance with ANSI B18.22.1. Provide lock washers in accordance with ASME B18.21.1. Provide U-bolts in accordance with ASTM A 307. Provide hot-dipped galvanized hardware in accordance with ASTM A 153 or mechanically galvanized in accordance with ASTM B 695, Class 50.

Provide certified material in accordance with ODOT Supplement 1092 or 1093.

730.09 Stainless Steel. Provide any AISI 300 or 400 series stainless steel.

Provide certified material in accordance with ODOT Supplement 1093.

730.10 Stainless Steel Hardware. Provide stainless steel hardware in accordance with ASTM A 320 (AISI 300 series). Provide bolts, screws, nuts, washers, handhole cover chains, and U-bolts from passivated commercial grade stainless steel.

Provide certified material in accordance with ODOT Supplement 1092 or 1093.

730.11 Aluminum Sheet and Plate. Provide sheets for extrusheet panels in accordance with ASTM B 209, 3003-H18, or 5052-H38. Provide sheets for flat sheet and overlay signs, and sign post reflectors, in accordance with ASTM B 209, 3004-H38, 5052-H38, or 6061-T6. Provide plates for sign support structures in accordance with ASTM B 209, 6061-T6.

Provide certified material in accordance with ODOT Supplement 1092 or 1093.

730.12 Aluminum Extrusions. Provide extruded panels and extrusions for extrusheet panels in accordance with ASTM B 221, 6063-T6. For sign support structures, provide rolled or cold finished bar, rod, and wire in accordance with ASTM B 211, 6061-T6. Provide extruded bars, rods, shapes, and tubes in accordance with ASTM B 221, 6061-T6.

Provide certified material in accordance with ODOT Supplement 1092 or 1093.

730.13 Aluminum Tube and Pipe. Provide seamless pipe and seamless extruded tube in accordance with ASTM B 241, 6061-T6. Provide extruded structural pipe and tube in accordance with ASTM B 429, 6061-T6.

Provide certified material in accordance with ODOT Supplement 1092 or 1093.

730.14 Aluminum Castings. Provide sand castings in accordance with ASTM B 26, 356-T6 or T7. Furnish self-aligning aluminum extrusheet sign mounting clips with manufacturer identification mark conspicuously incorporated in relief on the top surface of the casting, and in accordance with ODOT Supplemental Specification 992.

Provide permanent mold castings in accordance with ASTM B 108, 356-T6 or T7.

Provide certified material in accordance with ODOT Supplement 1092 or 1093.

730.15 Aluminum Forgings. Provide forgings in accordance with ASTM B 247, 6061-T6.

Provide certified material in accordance with ODOT Supplement 1092 or 1093.

730.16 Aluminum Welding Rods. Provide welding rods in accordance with AWS ER-4043.

730.17 Aluminum Hardware. Provide hardware in accordance with the following requirements:

	ASTM Designation	Alloy	Condition/ Temper
Bolts and screws	B 211	2024 6061	T4 T6
Studs-welded	B 211	1100	H16
Nuts-hex	B 211	6061 6262	T6 T9
Nuts-lock	B 211	2017	T4
Washersflat	B 209	Clad 2024 6061	T4 T6
Lock washers	B 211	7075	T6
Rivets-solid	B 316	6053 6061	T6 T6
Rivets-blind	B 316	2017 2117 5052	F F F

In addition, provide break-mandrel aluminum blind rivets with a stainless steel or aluminum mandrel.

Provide certified material in accordance with ODOT Supplement 1092.

730.18 Reflective Sheeting Type F. Provide sheeting in accordance with ASTM D 4956, Type I, including supplemental requirement S1.

730.19 Reflective Sheeting Type G. Furnish Type G reflective sheeting of microprismatic construction according to ODOT Supplement 1049, and according to ASTM D 4956, Type IV, including supplemental requirement S1. Do not furnish material of glass bead construction.

Provide materials in accordance with the City's QPL.

730.191 Reflective Sheeting Reboundable. Provide reboundable reflective sheeting in accordance with ODOT Supplement 1049, and in accordance with ASTM D 4956, Type III, IV, VIII, IX or XI, including supplemental requirements S1 and S2, with watermarks or other identification marks inconspicuously incorporated into the face of the sheeting on a repeating pattern, if necessary, to distinguish the sheeting from other similarly appearing sheeting.

Provide materials in accordance with the City's QPL.

730.192 Reflective Sheeting Type H. Provide Type H reflective sheeting in accordance with ODOT Supplement 1049, and in accordance with ASTM D 4956, Type VIII including supplemental requirement S1.

Provide materials in accordance with the City's QPL.

730.193 Reflective Sheeting Type J. Provide Type J reflective sheeting in accordance with ODOT Supplement 1049, and in accordance with ASTM D 4956, Type IX or XI, including supplemental requirements S1.

Provide materials in accordance with the City's QPL.

730.20 Nonreflective Acrylic Opaque Sheeting. Provide non-reflective acrylic opaque sheeting in accordance with ASTM D 4956, except do not provide sheeting incorporating optical elements.

730.22 Silk Screen Inks. Provide opaque and transparent process color inks used in the silk screen process accepted and warranted by the manufacturer of the reflective sheeting in accordance with ODOT Supplement 1049. Use inks providing a tough, durable film of uniform thickness and appearance on the sign surface. Provide transparent process color inks used in the reverse screen process in accordance with the Daytime Color Specification Limits table in ASTM D 4956.

730.23 Transparent Acrylic Electronic Cuttable Films. Provide transparent acrylic electronic cuttable films warranted by the manufacturer of the reflective sheeting in accordance with ODOT Supplement 1049. Use films providing a uniform appearance on the sign surface. Provide films in accordance with the Daytime Color Specification Limits table in ASTM D 4956.

730.24 Cantilever Offset Bracket. The universal cantilever offset bracket is a system comprised of an upper and lower heavy duty cantilever bracket bolted to a Type I or Type II double tee for supporting double sided finished street name sign blanks. The heavy duty universal cantilever offset bracket shall be fabricated from 304 stainless steel material and shall be structurally composed of a saddle, an insert and an offset plate. The saddle and insert shall be formed using 12 gauge stainless steel and the offset shall be formed from 14 gauge stainless steel. The heavy duty universal cantilever offset bracket shall be bolted to the Type II or Type III double tee with #10 - 3/16 inch x 5/8 inch UNC hex head bolts with nylon nuts and flat washers. The finished street name sign blank shall be between 0.063 inches and 0.100 inches thick and riveted to the double tee rail using 3/16 inch diameter aluminum rivets comprised of 3.5% magnesium alloy body with a carbon steel mandrel and shall be 1/2 inch long in accordance with 711.01. The sign blank cannot exceed a length of 72 inches, a total area of 9.5 square feet, weigh more than 16.75. For signs greater than 48 inches in length, a special assembly is required. This assembly shall consist of 2 cantilevered offset brackets placed back to back and placed on top and bottom of sign assembly and riveted to the appropriate double tee section. The signs shall be attached to the sign supports using a Type 201 stainless steel buckle-strap combination with the banding a minimum of 0.036 inches thick and 3/4 inches wide. For fabrication, see City of Columbus Standard Drawing(s).

Provide materials in accordance with the City's QPL.

ITEM 731 SIGN LIGHTING AND ELECTRICAL SIGNS MATERIAL

731.03 Changeable Message Sign, Electrical Type.
731.05 Internally Illuminated Fixed Message Sign.
731.06 Sign Flasher Assembly.
731.07 School Speed Limit Sign Assembly.
731.08 Flexible Conduit.
731.10 Timer with Enclosure.

731.03 Changeable Message Sign, Electrical Type.

A. General. Electrical changeable message signs consist of units or groups of units containing arrangements of pixels using electrical circuitry to display different messages.

Place signs in weatherproof cabinets. Integrate control logic units, load switches, monitor feedback circuits, power supply, etc., within the sign cabinet or mount within a separate weatherproof enclosure as required.

B. Message Type. Provide electrical changeable message signs of the limited message or unlimited message type.

Provide limited message signs containing pixels in an arrangement that when energized, selected pixels display two or more messages.

Provide unlimited message signs containing pixels arranged in full matrix or alphanumeric type modules positioned side-by-side to provide line units of the specified length. Use line units capable of displaying messages containing letters and numerals, limited only by the number of characters accommodated by the sign. Use line units capable of continually displaying alternating messages.

Provide materials in accordance with the City's QPL.

C. Display Type. Provide electrical changeable message signs consisting of lamp, light emitting diode, fiber optic, light reflecting, or hybrid types.

Lamp type changeable message signs consist of individual incandescent bulbs.

Light emitting diode changeable message signs consist of groups of individual light emitting diodes that, acting together, form individual character pixels.

Fiber optic changeable message signs consist of fiber optic bundles that transmit light from a remote source to form individual pixels.

Light reflecting changeable message signs consist of individual light reflecting panels.

Hybrid changeable message signs consist of individual light reflecting panels, each augmented by a light emitting pixel of the specified type. Display light emitting pixels for reflecting panels in the exposed position, and conceal or de-energize light emitting pixels for reflecting panels in the unexposed position.

Provide materials in accordance with the City's QPL.

731.05 Internally Illuminated Fixed Message Sign. Provide internally illuminated fixed message signs of the required legend and consisting of an opaque housing with a face of translucent plastic. If specified, provide double faced signs. Illuminate signs using interior lamps located to uniformly light the sign face.

Provide signs either with the legend on the exterior surface to maintain legibility when unlighted due to power failure, or with the legend on the interior surface to make invisible when unlighted. Apply the legend using black silk screening or by direct applied characters to white sign faces, unless otherwise specified. Design the sign faces for quick removal for maintenance, and provide faces with a safety chain or like device. If specified, shield the sign faces with sunscreens, louvering, or visors.

Provide cast, extruded, or formed housings made of corrosion-resistant material. Provide mounting hubs similar to traffic signal design. Provide weatherproof signs with drainage weepholes.

Provide the sign with the appropriate hardware for mounting by span wire, mast arm, pedestal top, or pole type bracket arms. Include fluorescent type lamps with ballast or LED light source.

Furnish materials according to the City's QPL.

731.06 Sign Flasher Assembly. Furnish beacons consisting of single traffic signal sections with 8 or 12-inch yellow lenses. Ensure that the flasher control unit flashes the beacons at a rate for each beacon of between 50 to 60 times per minute with the light period from one-half to two-thirds of the total cycle. Furnish flasher control units that have all solid state components and that meet NEMA TS-1, part 6. House control units within a weatherproof corrosion-resistant enclosure with a lockable door. Include the LED lamps.

Provide LED beacons from a manufacturer listed on the City's QPL for LED signal lamps.

Provide materials in accordance with the City's QPL.

731.07 School Speed Limit Sign Assembly. Provide yellow beacons sized at 8 inches or 12 inches. Provide flashers flashing the beacons alternately at a rate for each beacon of 50 to 60 times per minute with the light period from one-half to two-thirds of the total cycle. Equip the

assembly with a solar cell power array having cellular data communication with remote programming capabilities. Provide flashers having all solid state components and meeting NEMA TS-1, part 6. Provide the backing members with hardware compatible with the method of support.

Provide LED beacons from a manufacturer listed on the City's QPL for LED signal lamps.

Provide materials in accordance with the City's QPL.

731.08 Flexible Conduit. Provide galvanized steel flextube conduit with a waterproof PVC jacket in accordance with UL 360 for wiring of lighted signs. Conduit must be labelled clearly as Sunlight Resistant, meeting the requirements of NEC Art. 300 and 350.

Provide materials in accordance with the City's QPL.

731.10 Timer with Enclosure. Provide a timer that allows automatic sign operation for a minimum of 8 times per day and for selected days of the week. Provide a solid state timer with a back-up battery to maintain timekeeping and program memory for at least 48 hours. Provide a battery with a design life of 10 years under field conditions when power failures over the 10-year period would accumulate to 100 days. If installed outdoors, house the timer within a lockable, weatherproof, corrosion-resistant enclosure. Provide each enclosure with at least one padlock complying with 631.06.

Provide materials in accordance with the City's QPL.

ITEM 732 TRAFFIC SIGNAL MATERIAL

732.01 Vehicular Signal Heads, Conventional
732.02 Vehicular Signal Heads, Optically Programmed, 12-inch Lens
732.04 Vehicular and Pedestrian Light Emitting Diode (LED) Modules
732.05 Pedestrian Signal Heads
732.06 Pedestrian Pushbuttons
732.07 Loop Detector Units
732.08 Loop Detector Units, Delay and Extension Type
732.09 Foundations
732.10 Sleeve for Anchor Base Foundation
732.11 Signal Supports
732.12 Strain Poles
732.13 Wood Poles
732.14 Down Guy Assemblies
732.15 Pedestals
732.16 Conduit Risers
732.17 Cable Support Assemblies
732.18 Messenger Wire
732.19 Cable and Wire
732.22 Backplates

732.01 Vehicular Signal Heads, Conventional. Provide vehicular traffic signal heads conforming to the ITE "Vehicle Traffic Control Signal Heads" standard.

Traffic signals consist of specified assemblies of optical sections containing 8 or 12-inch diameter colored lenses (except for green sections; green sections use clear), a housing, a door frame with stainless steel hinge pins and latching device, gasketing, visor, wiring, and LED module in accordance with Section 732.04. Provide the standard wide angle type twelve-inch lenses. Supply the housing with a five pair (for 3- or 4-section heads or six pair (for 5-section heads) barrier-type terminal block (no quick-disconnect slip-on connectors acceptable), screw-mounted at each end and located in the red section. Provide the terminal block meeting UL E62622, CSA LR15364; IEC compliant; containing #10-32 x 1/4 inch (min) zinc-plated steel phil-slot screws installed between barriers with a nominal height 0.45 inch above the terminal plate and with a nominal opening width of 0.41 inch; rated for 30 amps; and having a breakdown voltage of 7500 volts RMS. Provide stainless steel bolts and washers for securing sections together, lens mounting hardware, door latching bolts, and hinge pins. Use door latching bolts fitting through a slot in the door. Fabricate the green and/or yellow indication doors on all 4- and 5-section heads to open in book-like fashion.

Fit each optical section with a cutaway type visor unless the City specifies other type visors or louvering. Provide visors at least 7 inches long for 8-inch lenses and visors at least 9 1/2 inches long for 12-inch lenses.

Design optical sections for assembly with all 8-inch, all 12-inch, or intermixed arrangements. Assemble using suitable hardware forming weatherproof joints with no light leakage from one section to another. Provide assembly arrangements containing the specified number of optical sections, lens size, lens color, and circular or arrow configuration. Assemble from one to a maximum of five sections as specified to form a signal face. Provide multi-way heads with appropriate top and bottom brackets with an opening in the center of the top bracket provided for mounting purposes. Correct signal face height inequalities for multi-way heads for proper accommodation between top and bottom brackets by the use of pipe spacers.

Provide signal heads with required mounting hardware. Provide signal face orientation to traffic by serrated rings or other devices on housing sections and mounting hardware. Permit adjustment in increments not greater than 5 degrees of rotation and not affected by wind gusts when locked. Provide galvanized steel or aluminum spacers and drop pipes 1 1/2 inches nominal pipe size (1.90 inch actual diameter).

A. Aluminum Vehicular Signal Heads

In conformance with the ITE "Vehicle Traffic Control Signal Heads" standard, provide signal heads cast of nonferrous corrosion resistant metal.

All exterior surfaces, as listed below, shall be painted using an approved liquid or thermoset powder material process. All visible elements of the signal mounting hardware shall be properly prepared, primed, and painted according to this specification. All painting shall be performed under controlled environmental conditions, and in accordance with all manufacturer recommendations pertaining to surface preparation, material handling, and application. The coating system used shall be durable, uniform, and weather resistant.

The inside surface of the visors shall have a finish of flat black. All other exterior surfaces of the signal head and hardware shall have a finish of Gloss Black to closely agree with Federal Standard 595B, Color 17038, or as specified in the plans.

B. Polycarbonate Vehicular Signal Heads

Signal heads and visors shall be constructed of Gloss Black polycarbonate plastic to closely agree with Federal Standard 595B, Color 17038, or as specified in the plans with visors as specified and meet ITE specifications. Proper exterior colors shall be obtained by use of colored plastic rather than painting. The interior surface of the visor shall be flat black.

C. Span-mounted Vehicular Signal Heads & Free-swinging Vehicular Signal Heads

Provide an aluminum, weatherproof tri-stud single wire entrance with three (3) 5/16-inch x 1 7/16-inch stainless steel studs, lock washers, and hex nuts with each signal head. Provide the weather head entrance with a minimum inside diameter opening of 1 1/2 inches, including any rubber or plastic grommet protecting the cable. The opening at the tri-stud end may be irregularly shaped, but it must have a minimum opening of 1 1/2 inches at its widest point and a minimum opening of 11/16 inch at its narrowest point. Use a tri-stud washer having the same opening at the entrance. Provide the top of the entrance with only one (1) clevis hole to accommodate a 5/8-inch stainless steel clevis pin. Provide the clevis attachment, measured at the center of the clevis hole, with dimensions no greater than 5/8 inch thick or greater than 1 3/4 inches in width. For span wire mounted installations, coat the wire entrance the same color as the vehicular signal head. For use on mastarms, coat the wire entrance the same color as the mastarm structure.

Fabricate the span wire hanger, provided with each signal head, with aluminum having a 5/8 inch stainless steel clevis pin capable of mounting to span wires up to 1/2 inch in diameter. Provide the hanger with two (2) U-type stainless steel mounting bolts with hex nuts and lock washers. Fabricate the hanger spacer with cast aluminum. Provide the clevis pin hole with a stainless steel bushing insert located a minimum of 2 1/2 inches from the top of the outside of the hanger.

For free-swinging vehicular signal heads on mastarm structures, use a 90-degree 3/4-inch clevis hanger with pins to allow the signal head swing freely on the arm. Coat the clevis hanger the same color as the mastarm structure. Fabricate the bushing with stainless steel.

D. Rigidly-mounted Vehicular Signal Heads

The attachment hardware shall consist of an aluminum gusseted tube with a PVC insert for the vertical component, a solid aluminum top arm kit, and an aluminum, open lower arm. The attachment hardware shall allow the cables entering the signal head to be installed through the lower arm rather than the upper arm. Signal heads shall be attached to the upper and lower arms using aluminum tri-stud assemblies.

The bracket shall be attached to the mastarm structure using a high tensile aluminum alloy clamp kit with stainless steel cables. The clamp kit shall be adjustable and allow the signal head to be installed plumb even when the mastarm is not level.

The brackets and clamp kits shall be coated the same color as the mast arm structure.

Provide materials in accordance with the City's QPL.

732.02 Vehicular Signal Heads, Optically Programmed, 12-inch Lens. Provide optically programmed signal heads with an optical system projecting an indication programmed for visibility only within boundaries of a specific area. Provide the optical system capable of veiling anywhere to within 15 degrees of the optical axis using procedures and opaquing material in accordance with the manufacturer's instructions.

Provide the signal sections conforming to applicable portions of the ITE standard and 732.01. Provide and mount optical sections with a 12-inch lens size alone or in combination with additional sections of optically programmed or conventional optics types to form signal faces and heads. Provide an optically programmed signal section that includes an LED module.

Provide balance adjusters, if specified, having a splined eyebolt design and splined external clamping body. Fabricate all assembly hardware with stainless steel.

Provide a visor with each signal section.

Provide cable entrance adapters of the tri-stud type with stainless steel hardware. Seal the entrance adapter on the signal with a neoprene gasket having a minimum thickness of 3/32 inch placed under the clamp washer in the top signal section to make a weatherproof connection.

Provide materials in accordance with the City QPL.

732.04 Vehicular and Pedestrian Light Emitting Diode (LED) Modules.

Provide vehicular and pedestrian LED lamps in accordance with the City QPL and plan specifications.

Furnish LED signal lamp units that meet or exceed all the requirements of the current Institute of Transportation Engineers (ITE) publications. Provide an LED module certified by the Intertek LED Traffic Signal Module Certification Program. Each unit shall have a decal indicating Intertek certification.

All LED signal modules shall be the latest model currently in production and new. The City will not accept equipment no longer manufactured, even if it meets the following specifications.

Provide LED signal modules conforming to the following criteria:

A. Physical and Mechanical Requirements

1. Identify each LED signal module on the back side with the following:

   (1) Manufacturer's name and trademark

   (2) Part number

   (3) Serial number (must be unique for each unit)

   (4) Voltage rating

   (5) Power consumption (watts and volt-ampere)

   (6) Vertical indexing indicator (i.e., "up arrow", or the word "UP" or "TOP") if the City requires specific orientation of the module

   (7) Date of manufacture (minimum information required - month & year)

   Provide single units with identification markings showing the type and color of the module. Mark Bi-Modals with module type.

   Place a label on each LED signal module certifying compliance to ITE standards for color and luminance.

2. Provide the LED traffic signal module as a single, self-contained device, not requiring on-site assembly for installation into an existing traffic signal housing.

3. The assembly and manufacturing process for the LED traffic signal module assembly shall be such as to assure all internal LED and electronic components are adequately supported to withstand mechanical shock and vibration from high winds and other sources. The LED signal lamp shall survive 3 drops of 42 inches onto a smooth concrete surface without any loosening or breaking of internal components, or change in operation.

4. Provide the lens of the LED signal module capable of withstanding ultraviolet light (direct sunlight) exposure for a minimum time period of five years without exhibiting evidence of deterioration.

5. Provide lenses a minimum of 1/8 inch thick, free of bubbles and imperfections capable of withstanding a 42 inch drop test. Provide lenses smooth on the outside with no external facets to prevent dirt and debris build up.

6. Provide each LED traffic signal module comprised of a UV stabilized polymeric outer shell, multiple LED light sources, and a regulated power supply.

7. Match the red or yellow tinted lenses to the wavelength (chromaticity) of the LED. Do not furnish green tinted lenses.

8. Use an optical assembly to diffuse the light output and provide uniform illumination across the entire surface of the lens and eliminate the visibility of the individual LEDs to the observer. Use the optical assembly for all ball modules. The City will consider use of the optical assembly on arrow and pedestrian modules as optional.

9. Design the LED traffic signal module for universal installation in both span wire and standard/stationary pole mount applications.

10. Provide the "Arrow" pattern produced by the Arrow LED traffic signal modules conforming to the VTCSH standard for color, size and shape. The City will not require Arrow LED traffic signal lamp units having a specific orientation or having a variance in light output, pattern or visibility for any mounting orientation.

11. Design the single pedestrian module to display a full "HAND" icon and a full "WALKING PERSON" icon complying with standards for this (icon) symbol for the size specified.

12. Provide LED traffic signal modules visible at 450 feet during sway conditions (extended view) until obscured by the visor.

13. Design the LED module to detect catastrophic loss of the LED load. Design the LED module to sense a loss of the LED load and present a resistance of at least 250K Ohms across the input power leads within 300 msec.

B. Electrical Requirements.

1. Incorporate a regulated power supply into each unit engineered to electrically protect the LEDs and maintain a safe and reliable operation. Design the power supply to provide capacitor-filtered DC regulated current to the LEDs per the LED manufacturer's specification.

2. Provide the LED traffic signal module to operate on a 60 Hz AC line voltage ranging as specified by ITE specifications. Install circuitry to prevent flickering over this voltage range. Use a nominal rated voltage for all measurements of 120 ± 3 volts RMS.

5. Provide two, captive, color coded, 600 V, 20 AWG minimum jacketed wires, 3 feet long, conforming to the National Electric Code, rated for service at 221°F, for an electrical connection.

6. For LED modules, use spade-type terminals securely attached to the units' lead wires.

7. Provide the LED signal capable to operate with a minimum 0.90 power factor.

8. Total harmonic distortion (current and/or voltage) induced into an AC power cabinet bus by any sample of 10 signal lamp units shall not exceed 20 percent.9. This value may be calculated using the root-mean-square combination of the measured harmonic distortion from one sample LED signal modules.

10. Design LED signal modules and associated on-board circuitry to conform to the requirements in Federal Communications Commission (FCC) Title 47, Sub Part B, Section 15 regulations concerning the emission of electronic noise.

10. Design the LED signal modules incorporating circuitry to show no evidence of illumination for input voltages below 35 volts. Illuminate (unregulated illumination) LED signal modules for all input voltages higher than 45 volts AC, but less than 80 volts AC. Provide for fully regulated illumination for applied voltages of 80 volts through 135 volts AC. Show proof of the intended function of this circuitry by connecting the lamps to a variable voltage source and slowly raising the applied voltage from zero volts up to 135 volts, and then slowly lowering the applied voltage from 135 volts to zero volts.

11. Provide proposed LED signal lamp units using less than or equal to the base wattage shown below at 77 °F.

Retrofit	Wattage
12@ R 12" Red Ball	12 or less
12@ Y 12" Yellow Ball	22 or less
12@ G 12" Green Ball	15 or less
12@ Y 12" Yellow Arrow	10 or less
12@ G 12" Green Arrow	l9 or less

C. Environmental Requirements.

1. Provide green and red LED traffic signal lamp units rated for use in the ambient operating temperature range of -40 °F to +166 °F. Provide yellow signal lamps rated at a range of -13 °F to +77 °F.

2. Provide a unit consisting of a housing creating a sealed watertight enclosure eliminating dirt contamination and allowing for safe handling in all weather conditions. Seal the LED signal module against dust and moisture intrusion per the requirements of NEMA Standard 250-1991 for Type 4 enclosures to protect all internal LED and electrical components.

D. Documentation Requirements. Provide each LED traffic signal lamp unit with the following documentation:

1. Installation instructions.

2. The manufacturer name, brand and model number of all LEDs used, the LED manufacturer's recommended drive current, and degradation curves.

E. Warranty. Require the manufacturer to repair or replace the LED signal module, if it exhibits a failure due to workmanship or material defects within the first 60 months of field operation.

Require the manufacturer to repair or replace the LED signal module if, when operating over the specified operating ambient temperature and voltage ranges, the unit fails to meet or exceed all minimum luminous intensity requirements as defined in the specifications during the first 60 months of field operation.

Provide LED signal modules with measured chromaticity coordinates conforming to the requirements for chromaticity in the specifications over the temperature range provided in the Specifications for the duration of the warranty period.

Provide a written warranty from the manufacturer against defects in materials, workmanship, and luminous intensity for LED signal modules for a period of 60 months after installation of LED signal modules. Provide replacement LED signal modules within 10 days after receipt of failed LED signal modules, at no additional cost to the City, except for the cost of shipping the failed units.

Require the manufacturer to repair or replace an LED pedestrian signal module if the signal module fails to attract the attention of a viewer or a that a viewer cannot read, (both day and night) at all distances from 10 feet to the full width of the crossing area when operated over the specified operating ambient temperature and voltage ranges.

Provide materials in accordance with the City QPL.

732.05 Pedestrian Signal Heads. Provide pedestrian signal heads that conform to the ITE specifications. Provide signal heads including complete 16-in. x 18-in., symbolic LED countdown units with full upraised hand and walking person symbols. Provide the left side of the signal head with an integral hand/walking person display, and the right side compartment with the countdown display. Provide the display numeral segments comprised of two rows of discrete LEDs. Design the signal heads to alternately display the symbol of an upraised hand in portland orange and the symbol of a walking person in white light. Do not provide outline style symbols. Provide material for housings consisting of cast or sheet, corrosion resistant, non-ferrous metal. Adequately reinforce the housings. Provide non-ferrous metal or polycarbonate material lens frames.

Provide glass or ultraviolet and impact-resistant plastic lenses displaying the legend with translucent symbols within an opaque black background.

Seal the lens to the door frame using a weatherproof seal. Provide an elastomeric gasket between the door frame and housing to ensure a dust and weatherproof seal.

Use a signal head design providing adequate dissipation of heat.

Provide pedestrian signal heads with two-piece hinged type brackets that support the signal head close to the pole.

Provide two-piece, two- hinged brackets of cast aluminum with stainless steel hinge pins, secured by a tamperproof bolt in the closed position. Provide hinged brackets to allow the pedestrian heads to swing away from each other. Provide a hex head type latch bolt for the mounting. Include a terminal block inside the pedestrian signal head housing. Design the mounting to allow attachment to the pole by banding (two (2) bands per bracket), bolting, or by lag screws for wood poles only.

Paint the exterior surfaces of the pedestrian signal head and the two-piece hinged bracket black. Paint interior surfaces of visors flat black.

Provide materials in accordance with the City's QPL.

A. Operation.

1. Design the display driver to allow individual LED failures without affecting other LEDs in the same display.

2. Provide the countdown timer of the "smart" type, capable of continuously sampling the timing intervals presented by the pedestrian signal load switch driver(s) to "learn" the programmed timing used by the controller.

3. During interval sampling time, make the countdown timer numerical display a blank.

4. Provide for a sampling time to determine interval settings taking a maximum of two complete signal cycles.

5. Provide the unit capable of displaying a countdown commencing at the onset of the pedestrian clearance interval and reaching zero at the end of the pedestrian clearance interval.

6. For any interruption of the flashing pedestrian clearance display, e.g., preemption or timing plan change, during a countdown, make the display immediately cause blanking of the countdown numerals. Require the countdown timer to "re-learn" the pedestrian clearance interval upon return to normal service after preemption or immediately following a change in walk clearance time associated with a timing plan change.

Provide materials in accordance with the City QPL.

732.06 Pedestrian Pushbuttons. Provide pushbuttons of sturdy construction and with components providing a pushbutton with normally open contacts and including all electrical and mechanical parts required for operation. Provide a sturdy and resistant design of the pushbutton and its associated contacts and housing capable of withstanding mechanical shocks and abuse. Design the pushbuttons to withstand a concentrated force of 50 pounds applied to the buttons or any exposed portion with no damage the unit or mis-adjustments to the contacts.

Provide a housing circular in shape with a curved back surface for mounting on poles of various diameters. Integrate the curved surface with the housing or supply an adapter with a flat back type housing. Attach the adapter to the housing by stainless steel machine screws. Provide the pushbutton with a barrier-type lug terminal for the attachment of field cable. Provide a hole threaded for a 1/2-inch pipe in the housing for conduit attachment purposes. Paint external surfaces yellow with enamel paint of Color 13655, Federal Standard 595B.Provide activation of the pushbutton by a Piezo-driven solid state switch with no moving parts. Design the pushbutton for a maximum required operational force of 3 pounds per foot). Design the pushbutton to emit a two (2) tone beep and display a momentary LED illumination when activated. Provide a raised or flush pushbutton with a minimum of 2 inches at its smallest dimension.

Provide pedestrian pushbutton signs of a minimum of 0.07-inch steel or 0.10-inch aluminum. Provide the legends and backgrounds with reflective sheeting for aluminum signs. Provide materials in accordance with the City QPL.

732.07 Loop Detector Units. Furnish loop detector units according to NEMA TS-2. Furnish loop detector units with an LED or LCD display indication of call strength ($\Delta L/L$ or equivalent). This display shall be a bar graph or numerical display with at least eight (8) discrete levels indicated.

Provide materials in accordance with the City QPL.

732.08 Loop Detector Units, Delay and Extension Type. Provide loop detector units complying with the requirements of NEMA TS-1, section 15, with the following modifications. Provide two-channel, shelf-mounted loop detector units powered from 120 volts. Provide delay and extension type loop detector units. Use solid state isolated output units for all controller applications where directly connected to a solid state digital controller unit. Provide conductors twisted three to five times per 1 foot in the cable harness for loop input pins.

Provide loop detector units with detector settings adjusted by the use of switches, dip switches, thumbwheels, or dials. Do not incorporate the use of any LCD type display in the loop detector units for the purpose of making changes to detector settings.

Provide materials in accordance with the City QPL.

732.09 Foundations. For strain poles, signal support poles, and decorative pedestal poles (Standard Drawing 4106), use steel anchor bolts conforming to ASTM F1554, Grade 105 and galvanized in accordance with 711.02. For standard pedestal poles (Standard Drawings 4100, 4101, 4102, 4103, and 4104) and cabinets, use steel anchor bolts conforming to ASTM F1554, Grade 55 and galvanized in accordance with 711.02. Provide galvanizing extending at least 2 inches beyond the threads. Provide bent ends or a drilled and tapped steel plate as shown on the plans.

732.10 Sleeve for Anchor Base Foundation. Use a galvanized corrugated pipe or a cardboard-like concrete form with the same diameter and depth dimensions as the specified foundation, as directed by the Engineer or as called for in the plans. Properly backfill around the sleeve, using a compactable granular material compacted in 4" lifts or a controlled density fill rated at 150 psi.

732.11 Signal Supports. Provide signal poles and mast arms with tapered tubes of a true continuous taper. Provide circular tubes or regular polygon tubes with six or more sides. Provide circular tubes with measurements of diameter at a specific point along the longitudinal axis not varying by more than 3/16-inch. Provide a tube taper between 0.54 and 1.3 percent. A rectangular, rounded-corner aluminum Pole Identification Tag with minimum dimensions of 1 x 3 x 0.040 inches shall be attached to the pole at a height of 6 inches above the base plate. The Pole

Identification Tag shall be clearly and deeply stamped with the Columbus Standard Drawing Number, Design Number, and the fabrication date of the pole (e.g., SCD 4120, DES. 12, 05-12) in characters with a minimum height of 3/8 in. Attach to the pole with four stainless steel 3/16 inch rivets.

Fabricate mast arms of the true continuous taper type in two portions joined by overlapping of sections, with the overlap measuring at least 1-1/2 diameters as determined by the largest diameter of the outer portion. Assemble the sections with a 5/8-inch minimum stainless steel or galvanized steel hex head through-bolt.

Provide no more than one longitudinal, automatically electrically welded seam on circular poles. Provide welded seams neat and uniform in appearance and having a thickness not less than the base material and a bead height not exceeding 1/16-inch. Provide a uniform thickness at each pole or arm cross-section, except at weld beads. Do not place transverse seams or welds on true continuous taper type poles or arms. Weld in accordance with 513.17.

Poles and arms, including base and arm clamp, bolt covers, handholes, and wire entrances shall be hot dipped galvanized when applicable after fabrication in accordance with 711.02. All visible elements of the signal support, and any other parts required to be coated or painted, shall be galvanized and then powder-coated or painted. All painting shall be performed under controlled environmental conditions, and in accordance with the paint manufacturer's recommendations pertaining to surface preparation, material handling, and application.

All structural steel products shall be galvanized on the interior and exterior surfaces as per ASTM A123. The exterior surface of all structural steel and aluminum products shall be properly prepared for the application of an exterior coating. The coating color on both steel and aluminum products shall match each other. It is the responsibility of the contractor to ensure that both product manufacturers match coating colors.

The inside of each pole assembly and pole accessories shall be galvanized. The inside area formed by the gussets, pole and pole flange plate shall also be galvanized to protect the area from corrosion. An opening shall be provided in order to galvanize the interior of the gusset area. This opening shall not hamper the structural integrity of the flange assembly. External surfaces of the mast arm structure shall be galvanized.

Pole structure surfaces shall be prepared for galvanizing by using a solvent cleaning method to remove dirt, oil, dust, grease and any other contaminant that will reduce the adhesion of the galvanizing. Mill scale, rust or any other foreign material not removed by solvents shall be removed using mechanical methods (per Steel Structures Painting Council: SSPC-VIS-1-67). Manufacturer recommended abrasive techniques shall be used to provide the proper profile for adherence to ASTM A123 galvanic coating. The galvanizing shall be properly prepared so the powder coating or paint will adhere to the galvanized support. The structure shall then be coated or painted as per plan. Each coating layer shall be properly cured before the application of the next coat. Dry thickness measurements for steel shall conform to section SSPC-PA2-82, Steel Structures Painting Council.

Exterior surfaces of all bolt and screw fasteners, washers, nuts, and other attachment hardware shall have a coating applied to them. Fastener threads shall not be clogged with coating material.

All exterior surfaces of the mast arm pole shaft assembly, mast arm assembly, two-piece base, all clamps, all wire entrances, all clevis hangers, all handhole covers, brackets, luminaire arms, finials, and pole and arm caps shall have a coating applied to them.

Do not use guy rods or truss-type arms. Provide poles and mast arms with attachment plates and gussets. Assemble using high-strength bolts with the connection developing the full moment-resisting capability of the arm. Do not allow the butt diameter of mast arms to exceed the nominal diameter of the pole at the point of attachment.

Fit poles with a welded-on cast or plate steel base designed to mount on an anchor bolt foundation.

Use steel anchor bolts conforming to ASTM F1554, Grade 105 and galvanized according to 711.02. Ensure that ends have a steel plate as shown on the plans.

Provide signal poles combining provisions for roadway lighting with an additional handhole located opposite the mast arm flange with the poles' J-hook located above.

When specified in the plans, provide blind half couplings for controllers. Plug any unused holes.

Provide materials in accordance with City QPL.

732.12 Strain Poles. Provide signal strain poles for the attachment of span wire made of steel tapered tubes in accordance with the requirements of 732.11. Provide all poles with a removable pole cap, and messenger wire clamps with clevis and shackle, unless otherwise specified. A rectangular, rounded-corner aluminum Pole Identification Tag with minimum dimensions of 1 x 3 x 0.040 inches shall be attached to the pole at a height of 6 inches above the base plate. The Pole Identification Tag shall be clearly and deeply stamped with the Columbus Standard Drawing Number, Design Number, and the fabrication date of the pole (e.g., SCD 4170, DES. 12, 05-12) in characters with a minimum height of 3/8 in. Attach to the pole with four stainless steel 3/16 inch rivets.

Provide anchor bolt foundation type strain poles including a welded-on cast or plate steel base, bolt covers, a handhole, and a J-hook, as required by 732.11, and also including at least one 2-inch cable entrance with a weatherhead and a welded blind half-coupling.

All exterior surfaces of the strain pole structure, bolt covers, attachment hardware, wire entrances, span wire clamps, handhole covers, brackets, and pole caps shall be galvanized and have a coating applied to them in accordance with the requirements of 732.11.

Provide materials in accordance with City QPL.

732.13 Wood Poles. Provide wood poles conforming to ANSI 05.1 "Specifications and Dimensions for Wood Poles", made of Southern Pine or Western Red Cedar full-length pressure treated.

732.14 Down Guy Assemblies. Provide expanding or screw type anchors capable of withstanding a guy tension of 8000 pounds when installed in firm moist soil. Ensure that each anchor rod is 5/8-inch minimum diameter, 8 feet minimum length galvanized steel with thimble eye.

Provide that all pole and attachment hardware is hot dip galvanized in accordance with 711.02.

Furnish 3/8-inch minimum diameter guy wire that conforms to 732.18 and ensure that all accessories have a rated loading strength equal to or greater than the messenger wire minimum breaking strength.

Furnish porcelain strain insulators of the wet process type.

Furnish an 8 feet minimum length guy guard made of impact and ultraviolet light resistant yellow plastic that is fastened to the guy wire.

Provide materials in accordance with the City QPL.

732.15 Pedestals. Fabricate pedestals for the support of traffic control equipment of 4-inch schedule 40 steel or aluminum pipe. Fit the steel pipe with a welded-on base of plate or cast steel, or if specified, thread the steel pipe into a gray cast iron transformer type base. Provide galvanized steel pedestals in accordance with 711.02. Thread aluminum pipe into an aluminum cast transformer type base. Design pedestals to mount on an anchor bolt foundation.

The coating color on both steel and aluminum products shall match each other. It is the responsibility of the Contractor to ensure that both product manufacturers match coating colors so that an excellent looking end product is achieved.

Each coating layer shall be properly cured before the application of the next coat. The application procedure shall be such to warrant a finish without delamination, blistering, or corrosion as per the minimum five (5) year repair warranty.

The coating process shall involve such steps as the following:

1. Mechanical preparation: Pedestal shafts shall be rotary-sanded to a satin-ground finish. This treatment will place a rough surface on these items so the base coating layer will have excellent adhesion.

2 Cleaning: The pedestal assembly shall be immersed in an alcoholic-phosphoric acid solution that will chemically clean these items. The cleaning solutions shall be kept at a nominal 70 degrees Fahrenheit. The bracket and pedestal assembly shall be immersed in the solvent solution for 5 minutes and then cold-water rinsed until all chemicals are washed off.

3. Conversion coating: The bracket and traffic pedestal pole assembly shall then be immersed in an amorphous chromate conversion coating solution for 5 minutes. The solution shall be maintained at 70 degrees Fahrenheit. This treatment will result in the formation of a surface film in which the film chemically bonds itself to the base metal by diffusion and becomes a part of the base metal. The bracket and pedestal assembly shall be cold-water rinsed. This surface will provide optimal adhesion and good stability for the color film so that it does not chip peel, or flake.

4. Primer coating: An aluminum primer shall be applied as required traffic pedestal pole assembly to further improve coating adhesion.

5. Final coating: Each coat shall be properly dried before additional coats are applied.

6. Drying: The pedestal pole assembly shall be thoroughly dried then protected for shipment.

Provide materials in accordance with the City QPL.

732.16 Conduit Risers. Provide risers with conduit and fittings in accordance with 725.04 for non-conductive cables and 725.051, schedule 80 PVC for conductive cables. Provide a weatherhead made of aluminum or galvanized ferrous metal and threaded unless otherwise specified.

732.17 Cable Support Assemblies. Use a cable grip with cable support assemblies of the proper size and strength for the cables made of the flexible "closed" or "split with rod" type, of stainless steel or tin coated bronze, and equipped with a single "U" eye bale. Provide the smallest cable grip meeting a minimum rated breaking strength of 250 pounds.

Provide slings for cable supports made from copper clad or galvanized multi-strand steel wire with an overall diameter of not less than 1/8-inch and a breaking strength of at least 400 pounds. Use thimbles to form eyes at each end of the sling with grooves to match the wire. Adjust the sling to the proper length with the wire at each thimble lapped and secured with split bolt clamps.

Provide materials in accordance with the City QPL.

732.18 Messenger Wire.

A. Wire. Furnish seven strand ASTM A475 Class B Utilities Grade or stronger messenger wire except 1/4-inch seven strand messenger wire must be Extra High Strength Grade or stronger. Furnish 1/4-inch seven strand ASTM A475 Class B High Strength Grade or stronger tether wire. Furnish all wire per ASTM A475 with the following modifications:

18.2 Tags are not required on lengths less than 1000 feet.

B. Accessories. For messenger wire ensure all accessories have a rated loading strength equal to or greater than 73 percent of the messenger wire minimum breaking strength. For breakaway tether installations, accessories within the turnbuckle-tensioned portion of the tether span shall have strength equal to or greater than 73 percent of the breaking strength of 1/4-inch, 7-strand ASTM A 475 High Strength Grade Wire rope, or 3460 pounds. Other portions of the tether assembly shall use accessories strength equal to or exceeding the wire rope used in that portion. S-hooks shall be made of mild low-carbon galvanized steel and of the wire size indicated on the plans; larger wire sizes and higher-strength steel S-hooks shall not be substituted. Safety tie wire shall be 304 or 316 stainless steel, 1×19 stranded, 1/8-inch with stainless steel wire rope clips. If used, lead sheet to wrap tether wire in breakaway anchors shall be commercially pure lead of thickness 0.030 to 0.042 inches.

Provide materials in accordance with the City QPL.

732.19 Cable and Wire. Provide cable and wire meeting the requirements of Table 732.19-1 and rated at 600 volts with conductors of copper unless otherwise specified. Indelibly mark the cable or wire jacket at intervals of not more than 6 feet with nomenclature stating the size, the type, the organization specifying the type, and the manufacturer's name or trademark.

Provide materials in accordance with the City QPL.

TABLE 732.19-1 CABLE AND WIRE

Cable or Wire	Number of Conductors	Wire Gage	Specification or type	Conductor Type	Notes
Signal Cable	As specified	As specified	IMSA 19-1 IMSA 20-1	Copper color coded, stranded	
Interconnect cable	As specified	As specified	IMSA 19-1 IMSA 20-1	Copper color coded, stranded	
	Twisted pairs as specified	As specified	RUS PE-39 IMSA 19-2 IMSA 20-2	Copper color coded, solid	
Loop detector wire	Single conductor	14 AWG	IMSA 51-5	Copper stranded	
Loop detector lead-in cable	Two conductor	14 AWG	IMSA 50-2	Copper twisted pair, stranded, shielded	
Power cable	Two or three conductor	As specified	UL: RHH/RHW/ USE or HHW, cross linked polyethylene with an insulation thickness of 0.045 inch (min.)	Copper stranded	[3]
Service cable	Two conductor (duplex)	As specified	UL: RHH/RHW/ USE or HHW, cross linked polyethylene with an insulation thickness of 0.045 inch (min.)	Aluminum, [1] twisted, stranded	[6]
Ground Wire	Single conductor		UL: RHH/RHW/USE or HHW, cross linked polyethylene	Copper stranded	[4],[5]

Notes:
[1] The Contractor may substitute copper conductors.
[2] ANSI/ICEA Cable shall have: Solid insulations, Full count color coding, 8-mil shield, and 772 kHz attenuation compliance. All other specifications are manufacturer's option unless specified.
[3] Three-conductor cable may be specified. Permitted substitution: 2 (or 3) single conductor cable.
[4] Minimum size is equal to the power or service cable, whichever is larger.
[5] Cable jacket shall be green with two (2) yellow tracers (stripes).
[6] Contains bare messenger (neutral).

732.22 Backplates. Provide backplates constructed of wrought sheet aluminum, in accordance with ASTM B 209, 6061-T6, 0.050 inch minimum thickness. Anodize the backplate base metal to maximize paint adhesion in accordance with Mil-A-8625, Type II or Type I. Provide backplates painted on both sides with at least two coats of flat black alkyd enamel paint or polyester powder coat (no epoxy) closely matching FED-STD-595b-37038. Provide a backplate extending 5 inches beyond the outside of the signal assembly on all sides. The overall outside shape of the installed backplate shall be an offset of the outline of the head. Fabricate the backplate allowing no gaps between the backplate and the signal head or between signal sections. Apply a 2- inch wide continuous outside border of yellow or fluorescent yellow reflective sheeting to the front face of the backplate. Use Type H or Type J reflective sheeting listed on the City's Qualified Products List. Provide all assembly and mounting hardware of stainless steel conforming to 730.10. If used, provide machine nuts of the thread-deforming or nylon locknuts types. Do not use rivets for mounting the backplate to the signal head. Use a minimum of four mounting points on each signal section for attaching the backplate. Provide all mounting hardware.

ITEM 733 TRAFFIC SIGNAL CONTROLLER MATERIAL

733.01 References and Definitions.
733.02 Controller Units.
733.03 Cabinet.
733.04 Cabinet Risers.
733.05 Flasher Controller.
733.06 Controller, Master, Traffic Responsive.
733.09 Uninterruptible Power Supply (UPS).
733.10 Foundations.

733.01 References and Definitions.

"NEMA TS-2," "Type TS-2/A2," and "Type TS-2/A1" refers to equipment manufactured in conformance with the National Electrical Manufacturers Association (NEMA) Standards Publication No. TS-2.

"NEMA TS-1" and "Type TS-1" refers to equipment manufactured in conformance with the National Electrical Manufacturers Association (NEMA) Standards Publication No. TS-1.

"IP" refers to equipment conforming to the Internet Protocol Suite communication protocols defined by the Internet Engineering Taskforce RFC 1122.

733.02 Controller Units.

A. General Requirements. Provide each controller unit with internal time based coordination and, if used in a hardwired coordination system, provide an internal communication device or transceiver for connection to interconnect cables or wireless system including multi-conductor 120 volt cables, twisted pair low voltage cables, coaxial cables, or fiber optic cables as shown on the plans.

If used in a closed loop system, provide the local intersection controller with all of the software features necessary to operate with the system requirements given in 733.06. Provide the necessary dial-up communications capability for isolated local intersections if part of the monitoring and control system. If the plans require a pre-timed operation for the signal timing and phasing configuration, provide the controller unit meeting all requirements of this section and capable of configuration in a pre-timed, sequential phase, fixed interval mode.

Provide nonvolatile controller memories not requiring batteries or other sources of energy to retain data while removing power from the controller.

Controller units shall meet the current Advanced Transportation Controller Standard Version 5.2b and draft version 6.10 and be fully downward compatible to NEMA TS-2 Type 2 or NEMA TS-1.

B. Software. Provide a communication port for connection to a laptop computer for database upload/download. Provide software for the personal computer to completely program all features of the controller unit. Unless otherwise shown on the plans, provide the controller unit with software with the following features even if not used by the signal phasing operation shown on the plans:

1. NEMA 8 phase, dual ring capability with four pedestrian movements, 4 overlaps, and the ability to program an exclusive pedestrian movement. Provide the controller capable of programming for sequential phasing operation. All controllers shall be capable of implementing Flashing Yellow Arrow operation by remapping pedestrian channel yellow drivers to operate the yellow arrows.
2. Volume density functions
3. Secondary coordination plans
4. Time of day/day of week scheduler
5. Time based coordination, minimum 3 dials, 3 offsets, 3 splits
6. Internal preemption for railroad and emergency vehicles. Railroad preemption shall conform to ODOT specifications.
7. Operator selectable single or dual entry in dual ring use
8. Security access codes
9. Detector features including delay timing, carryover (extension) timing and detector switching
10. Simultaneous gap out feature
11. If operated in a system, communication capabilities to interface with hardwired masters, dial up modems, and/or IP communication devices.
12. Data upload and download capability to a personal computer. At least one IP port and one serial port shall be included.
13. Storage of detector counts utilizing phase detectors for a minimum 24 hour period in 15 minute increments
14. Detector failure monitoring and logging features for constant calls and absence of calls

Provide the greater of either 60-month warranties or the manufacturer's standard warranty for the following equipment:

1. NEMA Controller Equipment

a. TS-2/A-2 Controller Units

b. Bus Interface Units

c. Malfunction Management Units

d. TS 1 Conflict Monitors

Provide warranties with the period beginning on the date the Contractor places the controller into service for permanent, uninterrupted operation. Attach a permanent label or stamp on each unit indicating the date of shipment. Label shall indicate the equipment vendor name and or logo.

C. Type TS-2/A2. Provide a controller unit meeting NEMA TS-2 specifications and suitable for shelf mounting. Provide a controller unit with all ports and input/output connectors for complete interchangeability between NEMA TS-1 and TS-2 cabinets. Provide controller settings programmable through a keyboard on the front panel. Provide an eight-line by 40-character display on the front panel. Ensure the controller is equipped with a datakey to support controller database upload/download. Securely attach the datakey to the top of the controller with fiber-reinforced tape at the time of delivery to the project.

Provide materials in accordance with the City's QPL.

733.03 Cabinet. Provide all cabinets complying with the requirements of this Section. Equip all NEMA specified cabinets as follows:

Supply a 16 position backpanel with a 16 channel NEMA TS-1 conflict monitor or NEMA TS-2 malfunction management unit.

Malfunction management units shall have an LCD display.

Provide each cabinet main door with a sturdy, permanently lubricated lock covered with a weatherproof tab. Key the project locks to the City of Columbus master #2 key (1R 6380). Supply two keys with each lock. Also, equip the small door-in-door with a lock keyed to the City of Columbus master R4266 key, covered with a weatherproof tab. Provide the door-in-door lock with a lock keyhole cover. The door handle shall swing out away from the door edge, not toward the center of the door.

Any fasteners (rivets, bolts, etc.) that penetrate the cabinet exterior shall be tack-welded or brazed on the inside surface to prevent punch-thru if the fastener head is ground off from the outside. The preferred method of cabinet construction uses no such fasteners, but internal welds only.

Furnish cabinet with drawings that show the following:

1. Intersection map. The map shall include street names, all lanes, crosswalks and stop bars, all vehicle and pedestrian phases, all loops and detection zones, vehicular and pedestrian signal heads, and pedestrian pushbuttons. All of these features shall be labeled. Include a legend that shows the type of vehicular and pedestrian heads and north.
2. Field wiring hook-up chart for all signal heads. The chart shall include signal head name, signal head display indication, and field terminal on back panel.
3. Conflict Monitor/MMU channel assignments and functions, switch positions, and settings. Also show program card jumper locations diagrammatically (if applicable). If the Conflict Monitor/MMU is programmed via methods other than a program card detail this diagrammatically.
4. Legend with all wire gauges and insulator colors used in the cabinet. Apply this legend to all wiring shown in the drawings. Also include components such as MOVs and diodes.
5. Detector panel wiring. Detail all detector landings.
6. All cable and wiring harness pin assignments.
7. Detector rack layout. Label detector number and associated phase.
8. SDLC cable assignments.
9. Pedestrian pushbutton wiring.
10. Load switch assignments.
11. Flash programming buss and field terminals wiring.
12. I/O board, load switch, and flash transfer relay wiring.
13. Any video, radar, preemption, or other device wiring, interface, and cabling details.
14. UPS as-built schematic (if applicable). Detail all connections to cabinet and controller.
15. Netlist detailing all connectivity of the cabinet. It shall include all instances in the cabinet. Provide a description of all instances.

A. Type TS-1.

1. Cabinets. Provide a NEMA 3R cabinet of standard size with a complete back panel, as shown in the plans, providing ample space for housing the controller unit and all associated electrical devices furnished with it, together with any other auxiliary devices, as specified. Provide a cabinet with sufficient shelf space to accommodate all existing, proposed, and designated future equipment. Provide space to accommodate the appropriate controller unit frame as designated in NEMA TS-1, Section 14.

Provide a smooth exterior with no sharp edges. All exterior seams shall be either continuously welded, tack welded, sealed with a 15 to 20 year silicone sealer, and/or overlapped such that water does not enter the cabinet. Provide a rigid cabinet designed to support all components.

Provide cabinet exterior surfaces of bare aluminum. When the plans specify a cabinet color, prime and finish all cabinet exteriors with two coats of high-grade enamel paint of the specified color. Paint the cabinet interior surfaces flat white. Treat the interior surfaces of the cabinet with a three (3) stage iron phosphate coating and a zinc chromate primer coating. Apply a baked white alkali enamel finish. Apply and dry all coatings of the inside white paint to prevent peeling for a guaranteed period of two (2) years.

Provide the cabinet with at least one rain-tight louvered vent equipped with a replaceable filter. Install vents to allow for the release of excessive heat and any explosive gases that might enter the cabinet.

Provide cabinets with a functional design having a door in the front providing access to substantially the full interior area. Double flange the cabinet door frame opening on all four sides. Attach a gasket of elastomeric neoprene material to the cabinet or door to form a weatherproof seal. Provide a heavy gauge continuous door hinge with a stainless steel hinge pin. Bolt the hinge to the cabinet for removal of the door. Make the bolts and nuts of stainless steel, tamperproof, and securely fastened to prevent vibrations from loosening the nuts. Equip the door with a three (3) point latching mechanism and a handle that will take a padlock. Provide a door stop to retain the door in an open position at 90, 135, and 180 degrees.

Include a small, hinged, and gasketed door-in-door (police door) on the outside of the main controller door. Provide the cabinet with a door-in-door design not allowing entrance to the controller mechanism nor to exposed electrical terminals, but provides access to a small switch panel and compartment (police panel).

Fit the cabinet with the necessary provisions for mounting, with a bottom conduit connection provided for pole-mounted cabinets. Provide suitable hardware and equipment for each cabinet mounting method, including bolts for drilled and tapped holes on metal supports, pole attachment clamps, and pedestal slipfitter.

Directly place all equipment designed for shelf mounting on a shelf except for loop detector units (amplifiers) and similar devices designed for stacking on each other. Arrange components on shelves and devices on the door so that a 1-inch minimum space separates for the door in a shut position. Do not allow plugs, wires, controls, or similar items to compromise this space.

Reserve a minimum 4-inch clear area on the bottom of the cabinet for the routing of cables. Do not locate panel mounted equipment in the bottom 6 inches of the cabinet. Do not locate shelves or components within 6 inches of the bottom of foundation mounted cabinets.

Arrange all equipment for easy withdrawal and replacement, without the necessity of disturbing adjacent equipment. Permanently locate devices within the cabinet to allow free circulation of air and not to restrict air flow from fan ducts or vents.

Provide auxiliary equipment capable of operating within a weatherproof cabinet at ambient temperatures between -30 and 165 °F.

For terminals and panel mounted devices with exposed electrical contact points located next to shelf mounted equipment, provide spacers, shelf lips, or other means to prevent accidental movement of component units into contact with any exposed electrical terminal points.

Provide for ready accessibility to load switches, relays, flashers, fuses, switches, terminal blocks, and other equipment mounted or plugged into the back or side panels. Provide visibility and easy operation to switches, controls, and indicator lights without moving the components from their normal shelf positions.

Furnish LED strip lighting for internal illumination.

Provide materials in accordance with the City QPL.

2. Accessory Equipment.

a. Ventilating Fan. Equip all cabinets with a forced air ventilating fan. Provide a fan that provides a capacity of at least 100 cubic feet per minute. Provide a fan thermostatically controlled and adjusted to start at cabinet temperatures above 120 °F and to stop at a temperature below 100 °F.

b. Load Switches. Provide all cabinets with solid state, triple-signal load switches complying with NEMA TS-1, Section 5. Additionally, provide all load switches having both input and output indicators.

c. Conflict Monitor. Provide all cabinets with a separate solid-state conflict monitor device. Provide cabinet wiring that transfers the signals to a flashing condition during a monitor disconnection. Provide conflict monitors complying with NEMA TS-1, Section 6. Additionally, provide conflict monitors capable of causing the signals to flash as a result of the following events:

i. All burned out red lamps associated with a load switch;

ii. Within one second after the display of red and green, or yellow and green color pairings on the same phase;

iii. The absence of a minimum yellow interval.

Provide a monitor capable of indicating the exact load switch output channel where the failure event occurred. Provide conflict monitors capable of storing a minimum of nine fault events (event logging feature). Provide a monitor utilizing an LCD display and including an RS-232 port for connection to a laptop computer. Provide software and connector cables to diagnose the conflict monitor.

d. Flashers. Provide solid-state flashers complying with NEMA TS-1Section 8. For signals having a normal stop-and-go sequence that includes flashing, provide controller unit that generates the flashing display or provides flashers. For this purpose, provide separate flashers from those provided for emergency back-up. Provide flashers designed with two circuits of at least 10 amperes each.

Equip each controller cabinet with terminals wired to allow the interchange of jumpers and arrange the flashing operation to display either flashing yellow or flashing red on the vehicular signals.

e. Relays. Provide completely wired relays required for proper operation of the specified equipment. Provide readily replaceable, enclosed relays designed for one-million operations without failure or need for adjustment.

f. Surge Protection Devices. Provide surge protection on incoming power lines, interconnect lines, and detector leads.

Provide an EDCO SHA-1250 primary surge protection device (SPD) or approved equal. Use a plug-in base to hold the device. Attach all wiring connections to the base and maintain appropriate cabinet clearances to allow replacement of the SPD module by hand without the use of tools.

Provide loop detector lead-in cable protection consisting of devices installed in each detector circuit where the lead-in connects to the terminal block. House each device in a case consisting of two stages; a 3-electrode gas tube arrestor and a semiconductor circuit. Provide an arrestor that shunts to ground a common mode transient with a 1,000 ampere peak and an 8/20 microsecond wave-shape, ionizing at 400 volts within 100 nanoseconds when subjected to a 1,000 volt per microsecond transient. Provide a semiconductor circuit that clamps a differential transient to 30 volts within 40 nanoseconds of the appearance of the transient, and a common mode transient to 30 volts within 500 nanoseconds of the ionization of the gas tube arrestor. Provide a second stage capable of withstanding a peak current of 13 amperes. Provide a device with impedance characteristics compatible with the detector unit to prevent false calls or increase the loop impedance above the sensitivity of the detector unit.

Provide pedestrian pushbutton inputs with the same protection as specified for the loop detector lead-in cables.

Protect interconnect cable against transients by devices across each conductor of the cable and ground. Use either 2 or 3-terminal devices. If using 3-terminal devices, connect two conductors and ground to the same device. Provide a protection device consisting of a gas tube arrestor with a maximum ionization voltage of 1000 volts on a 10,000 volt per microsecond transient or a maximum ionization voltage of 950 volts on a 3000 volt per microsecond transient. Allow the maximum time from beginning of the transient to ionization of 1.1 microseconds on a 10,000 volt per microsecond transient. Provide a device not ionized by normal voltage variations on a 120-volt AC line. Provide a device capable of withstanding a 10,000 ampere peak with an 8/20 microsecond waveshape.

g. Main Power Breaker. Provide an incoming AC+ power line controlled by a main circuit breaker rated at 240 volts and an auxiliary breaker, with capacity and wiring as specified in NEMA TS-1, Section 10.3.2.2 and Figure 10-4.

For a power service disconnect switch located before the controller cabinet, do not connect the neutral (AC-) and the grounding bar in the controller cabinet as shown in NEMA TS-1, Figure 10-4.

h. Radio Interference Filter. Provide an incoming AC+ power line containing a radio frequency interference (RFI) filter installed between the main circuit breaker and the solid state equipment. Also, provide RFI filtering for the load switches and flasher, unless the equipment furnished provides signal and flasher circuits switching at the zero voltage point of the power line sinusoid wave form.

i. Convenience Outlet and Light. Wire a convenience outlet into the cabinet for use by electrical maintenance equipment. Provide the outlet with at least one standard duplex three-wire NEMA 5-15 receptacle of the ground-fault circuit-interrupting (GFCI) type. Wire a second non-GFCI convenience outlet, not fed thru the UPS system (if used). Provide and mount a white LED lamp in the upper portion of the cabinet. Provide a door switch to control the convenience light.

j. Manual Control and Pushbutton. When required by the plans, provide intersection controller units with the capability to switch to manual operation of interval timing from automatic interval timing. Provide for manual operation capable of the same interval sequence as for the automatic operation.

Obtain manual interval timing by a momentary pushbutton contact switch mounted on a 5-foot minimum flexible weatherproof extension cord. Store that switch and cord behind the small door-in-door.

k. Switches. Provide completely wired switches required for proper operation of specified equipment. Clearly and permanently label switches according to function and setting position, and make accessible without the necessity of moving components.

i. Signal Shutdown Switch. Provide a cabinet with a signal shutdown switch for turning off the power to the signals at the intersection. Provide a switch only affecting the power to the signals, and allowing the controller to continue in operation. Locate the switch in the panel behind the small door-in-door (police door).

ii. Auto/Flash Switch. Provide a cabinet with a flash control switch for activating the flashing of vehicular signals in a preselected emergency flash display. Ensure that the operation of the flash control switch causes a flashing display even under conditions of controller unit malfunction or of its removal from the cabinet. Ensure that the operation of the switch overrides any operation commands from a local or remote time switch. Locate the switch in the panel behind the small door-in-door (police door).

Program the transfer to and from flashing operation, when called remotely or by a local time switch, to occur only at points in the cycle allowed by the OMUTCD.

iii. Automatic/Manual Transfer Switch. Provide a cabinet with an automatic/manual transfer switch. In the automatic position, make the controller unit automatically sequence the signal head displays. In the manual position, make the signal phase or interval sequencing occur only upon manual activation of the manual control pushbutton. Locate the switch in the door-in-door (police door). Allow switching from manual to automatic operation, or vice versa or making any time adjustments to occur at any time.

iv. Run/Stop-Time Switch. Provide a cabinet with a run/stop-time switch capable of activating the controller stop-time feature when in the "stop-time" position. Locate the run/stop-time switch on a switch panel in the cabinet.

v. Controller Shutdown Switch. Provide a cabinet with a controller shutdown switch capable of cutting off power to the controller unit, conflict monitor, and detector units. Do not allow the controller shutdown switch to cut power to those components required to maintain flashing operation. Locate the controller shutdown switch on a switch panel in the cabinet.

vi. Coordinated/Free Switch. Provide controllers operated in a coordinated system with a coordinated/free switch. Provide a switch allowing the choice of operating the controller under the supervision of a coordination device or operating the controller independently of coordination control. Locate the coordinated/free switch on a switch panel in the cabinet.

vii. Detector Test Switches. Provide momentary contact switches capable of entering a vehicular or pedestrian call for any actuated phase. Provide a switch for each actuated phase vehicular and pedestrian detection input. Conveniently group and label the switches.

l. Terminal Blocks. Provide cabinets that include terminal blocks mounted on panels on the walls of the cabinet. Place the blocks in locations not obstructed by shelf-mounted devices. Provide sufficient terminal sets for each individual harness wire as well as for contacts of signal load switches, flasher transfer relays, flasher, and other components. Also, provide separate terminal sets for field wiring connections, including power, signal, interconnection, and detector lead-in cables. Group terminal sets to separate higher voltage (120 VAC) from lower voltage, and arrange them into logical groups. Protect terminal blocks from accidental contact during the installation and removal of shelf-mounted equipment. Locate the blocks no closer than 4 inches from the bottom of pole and pedestal mounted cabinets, and no closer than 6 inches from the bottom of foundation mounted cabinets.

Provide the terminal points UL listed as suitable to carry the rated loading. Provide the capacity and size of the terminals as specified in NEMA TS-1, Section 10.2.5. Provide terminal points for signal field wiring for each circuit capable of accommodating at least four 12 AWG conductors with spade type terminals.

Provide terminal points for incoming power wiring capable of accepting either spade terminals or bare stranded wire, and suitable for either aluminum or copper conductors.

Space terminal sets for easy wiring. Provide at least six reserve terminal sets for controllers. Harnesses may terminate on the back of terminal blocks using through-panel terminals. Clearly mark terminal sets for ready identification including through-panel terminals identified on both sides. Make the contact between adjacent terminal points by bus bar, or by wire jumpers having spade type terminals securely attached to each end.

m. Terminal Buses. Provide a cabinet with supply terminal buses fed from the line side of the incoming 120 VAC power line, after the phase wire has passed through the main power switch. Use radio interference filters in accordance with Item 8 of this section, with the buses supplying load switches and with flashers filtered when required. Provide a signal bus relay controlling power to the bus supplying power for the signal load switches.

The following requirements override NEMA requirements for signal bus relays. Use a solid-state relay for the signal bus relay. Maintain output from the signal bus relay equal to or above the rating of the cabinet main overcurrent protection device over the NEMA TS-2 Environmental Operating Range of -50 to +185 degrees F.

Provide a common terminal bus for the connection of the neutral wire of the incoming 120 VAC power line. Provide a common bus with sufficient terminal points to accommodate all potential cabinet wiring as well as field wiring. Use a separate common terminal, insulated from the panel, for the interconnect common.

Provide bus terminal points complying with Item 12 of this section for conductor accommodation, attachment, and identification.

n. Grounding System/Bus Bars. Provide a cabinet that includes a grounding system as specified in NEMA TS-1, Section 10.3.2.1 with an adequate number (minimum of three) of ground terminal points.

o. Wiring. Neatly organize and route the harnesses and wiring bundles to individual terminals. Use harnesses providing a wire for each pin or contact of the device. Connect each wire to a marked terminal position. Use labeled spade type terminals or plug connections on all harness wiring. Group and lash or restrain wire bundles to not interfere with the access to components, terminal blocks or buses, or the legibility of terminal identification. Provide harnesses of sufficient length to reach any point within the cabinet. Provide capability to easily trace the cables and harness bundles through the cabinet to their terminations.

Wire the cabinet so that controller pin connections associated with a given phase number match the phase number assigned to the specified traffic movement as shown on the plans.

Provide all wiring with stranded conductors. Provide adequate wiring for the voltage and load representing the ultimate load of the devices connected. Provide wires with the ampacity rating as specified in NEMA TS-1, Section 10.3.3.1. Color code the wiring as follows:

i. Solid white, AC common.

ii. Solid green or green with yellow stripes, equipment ground.

iii. Solid black, AC line side power (AC+).

p. Loop Detector Units. Provide loop detector units complying with the requirements of NEMA TS-1, Section 15, with the following modifications:

i. Provide shelf mounted loop detector units powered from 120 volts.

ii. Provide a unit using solid-state isolated output devices.

iii. Provide conductors twisted three to five times per foot in the cable harness for loop input pins.

iv. Provide detector unit electrical connection plugs or wiring harness designed to allow replacement of any multi-channel shelf mounted detector unit with single channel detector units. Provide only units with the connector type required for single channel shelf mounted detector units, or wire the controller back panel to single channel wiring harnesses plug connected to an adapter harness and mated to the multi-channel connector of the detector unit.

v. When shown on the plans, supply delay and extension timing capability on the detector unit; otherwise, provide these features with the controller unit software in accordance with requirements of 733.02.

vi. Provide a harness with a wire for each pin or contact of the device.

vii. Provide loop detector unit with an LED or LCD display indication of call strength (ΔL/L or equivalent). Provide a display with a bar graph or numerical display with at least eight (8) discrete levels indicated.

If required by the plans, provide vehicle detector types other than "loop" detectors, by separate bid item.

Provide TS-1 cabinets in accordance with the City QPL.

B. Type TS-2.1. Furnish TS-2 cabinets that utilize a high speed data channel to connect the controller unit, malfunction management unit, rear panel (terminals and facilities), detectors and bus interface units and also comply with the general requirements of 733.03. Furnish a prewired cabinet with malfunction management unit, loop detector units, and all accessory equipment as specified in NEMA TS-2, except as follows:

a. Section 5.3.4, use detector racks for both Type 1 (A1) and Type 2 (A2) controller units.

b. Section 5.4.2.1, if a power service disconnect switch is located before the controller cabinet, the neutral (AC-) and the grounding bar in the controller cabinet shall be connected together.

c. Section 5.4.2.7, provide an LED type light.

d. Section 5.4.2.7.2, provide the LED lamp.

e. Section 5.4.2.7.3, provide the door actuated light switch.

f. Section 6.5.2.2.1, provide 2-channel detector units, without delay/extension features (Type A). Furnish momentary pushbuttons on the cabinet door or a detector rack panel for actuation of Detector BIU #9, channels 1-16, and the four opto-isolated pedestrian detector inputs on BIU #1 and BIU #2. Permanently label these pushbuttons as "VEH DET 1" through "VEH DET 16" and "PED DET 1" through "PED DET 8."

g. Section 7.2, construct cabinets of sheet aluminum.

h. Section 7.3, unless otherwise specified in the plans, provide a stretch M36 cabinet (61" ± 3" H x 36" W x 17" D) for pole mounted cabinets, NEMA Size 6 for ground mounted cabinets.

Furnish all wire passages through and over metal edges with edge protection polymer trim.

i. Section 7.5.7, ensure that the police panel contains switches for AUTO/FLASH, SIGNALS ON/OFF and AUTO/MANUAL in the police panel. The AUTO/FLASH switch shall activate the MMU Local Flash input. This will cause the controller to start in its programmed start phases/colors when switched from FLASH to AUTO position.

Furnish a pushbutton with a 5-foot (1.5 m) cord, and panel connector, not hard wired, unless a strain-relieving panel feed-thru bushing is provided.

j. Section 7.7.3, supply cabinets with an unpainted exterior. Paint the interior surfaces flat white. Treat the interior surfaces of the cabinet with a three (3) stage iron phosphate coating and a zinc chromate primer coating. Apply a baked white alkali enamel finish. Apply and dry all coatings of the inside white paint to prevent peeling for a guaranteed period of two (2) years.

2. Furnish loop detector and pedestrian inputs that have lightning/surge protection as specified in 733.A.1.f.

3. Include 16 channel loop detector racks with the necessary number of two-channel loop detector units with the cabinet. When shown on the plans, supply delay and extension timing capability on the detector unit; otherwise, provide the controller unit software with these features. If vehicle detector types other than "loop" detectors are required by the plans, provide these detector units by separate bid item. If the special bid detector units use standard TS-2 detector racks, furnish the racks as part of the pre-wired cabinet.

Furnish loop detector unit with an LED or LCD display indication of call strength (ΔL/L or equivalent). This display shall be a bar graph or numerical display with at least eight (8) discrete levels indicated.

4. Furnish switches to control the controller unit and cabinet functions as specified in the plans.

5. Furnish load switches that have both input and output indicators. Eight load switch sockets shall be positioned horizontally and stacked in two rows on the main panel.

6. Cabinet power distribution shall conform to Figure 5-4, NEMA TS-2 2003 v02.06. The power panel shall not integrate into the main panel and should be located on the lower right wall of the cabinet. The power panel shall be wired to provide the necessary filtered power to the load switches, flasher(s), and power bus assembly. The power panel portion of the main panel shall include the following components:

a. A minimum of one (1) main breaker.

b. A minimum of one (1) auxiliary breaker.

c. A primary surge protection device (SPD). The SPD shall be an EDCO SHA-1250 or approved equal. A plug-in base shall be used to hold the device. All wiring connections shall be made to the base, and appropriate cabinet clearances maintained, to allow the SPD module to be replaced by hand without the use of tools.

d. Signal Bus Relay. A solid-state relay shall be used for the signal bus relay. This relay shall maintain output equal to or exceeding the requirements of the cabinet main overcurrent protective device over the NEMA TS-2 Environmental Operating Range of -30 to +165 degrees Fahrenheit.

e. A minimum of one (1) 8-position neutral bus bar.

f. A minimum of one (1) 6-position ground bus bar.

g. A minimum of one (1) convenience receptacle.

7. Include datakey module. Provide a datakey with each controller, taped securely to the top of the controller chassis.

8. Include an SDLC expansion board with three available ports, mounted on a cabinet side wall.

9. Include an SDLC in-line surge suppressor for the controller, EDCO SRS-BIU-15 or equivalent, located at the SDLC serial bus.

10. Furnish an aluminum shelf with integral storage compartment in the space immediately below the controller. Ensure the storage compartment has telescoping drawer guides for full extension. Ensure the compartment top has a non-slip plastic laminate attached.

11. The following cabinet alarm inputs shall be provided: door open, manual control, local flash, and conflict flash.

12. A six outlet duplex receptacle shall be provided above the controller shelf for sensitive electronic network equipment. The outlet shall be connected to the protected side of the main cabinet plug in surge arrestor base and powered independently of the UPS. The outlet shall be clearly labeled "SURGE PROTECTED OUTLET".

13. Include an MSA harness to provide power to a NEMA TS-2, Type 2 controller.

Furnish TS-2 cabinet according to the City's QPL.

C. Type 334L.

1. General. Furnish Model 334L cabinets that meet the specifications "Traffic Signal Control Equipment Specifications" and "Transportation Electrical Equipment Specifications", California Department of Transportation. Ensure that the manufacturer of the cabinets is listed on the CalTrans QPL at the time of the project award.

2. Cabinets. Furnish cabinets that are constructed of aluminum and are supplied unpainted. An anodic coating is not required. Supply galvanized anchor bolts with nuts and washers with each cabinet. Furnish 3/4-inch diameter by 16 inches minimum length anchor bolts with an "L" bend on the unthreaded end.

3. Terminals and Wiring. Ensure that the vehicle detector field wiring inputs connect to side mounted terminal blocks. Install terminal blocks and associated wiring to the input file. Label the field wiring terminals of the side mounted terminal block by a permanent screening process to identify the input panel (I), the input file slot number (1 through 14) and the channel terminal (D, E, J, or K). An example is "I4-E". Ensure that all terminals on these detector blocks are accessible without removing equipment from the EIA mounting rack.

4. Accessories.

a. Fully equip the cabinets with two channel loop detector sensors, transfer relay, power supply, conflict monitor and switchpacks. When ramp meter warning signs with flashers are used, include a NEMA or Caltrans type flasher wired for control from the controller.

b. Furnish a police panel in each cabinet with the Caltrans required switches. No pushbutton with cord is provided.

c. Furnish an aluminum shelf with integral storage compartment in the rack below the controller. Ensure that the storage compartment has telescoping drawer guides for full extension. Ensure that the compartment top has a non-slip plastic laminate attached.

d. Ensure that each cabinet has two fluorescent lights installed at the top of the cabinet, one near each door. Wire the lights to the door switches such that opening either door will turn on both lights.

5. Lightning/Surge Protection. Comply with the requirements of 733.03.C.5.

6. Conflict Monitor. Furnish a Model 208 conflict monitor unit.

733.04 Cabinet Risers. Provide the type (size and shape) of cabinet riser compatible with the type of controller cabinets specified for the project.

Provide an aluminum riser capable of raising the NEMA cabinet either 12 inches or 30 inches above the concrete foundation, as shown on the plans. Bolt the bottom of the riser to the standard cabinet foundation (anchor bolts not included with the riser) and the top of the riser bolts to the bottom of the cabinet. Provide attachment hardware for connecting the riser to the cabinet.

Construct the riser in a minimum of two pieces to allow raising the existing cabinet off the foundation without disconnecting the field wiring and inserting the riser below the cabinet. Provide hardware for rigidly connecting the riser sections together.

Fabricate the riser from 0.125-inch sheet aluminum with flanges on the top and bottom to provide rigidity. Provide mounting flanges as necessary to connect with the controller cabinet and foundation anchor bolts. Provide the outside surface of the riser with a smooth, uniform, natural finish.

Cabinet Riser for Type 334 Cabinet. Furnish an aluminum riser that will raise the Model 334L cabinet approximately 8 inches above the concrete foundation. Ensure that the bottom of the riser bolts to the standard cabinet foundation anchor bolts (not included with the riser) and the top of the riser bolts to the bottom of the cabinet. Furnish attachment hardware for connecting the riser to the cabinet. Manufacture the unit to CalTrans specifications. Ensure that the outside surface of the riser has a smooth, uniform, natural finish unless controller cabinet painting is shown on the plans. If painting is required, prepare and paint the riser to match the cabinet.

Provide materials in accordance with the City QPL.

733.05 Flasher Controller. Provide a solid-state flasher complying with NEMA TS-1, Section 8, and having two circuits, each rated at 10 amperes. Provide a cabinet conforming to applicable requirements of 733.03.A, except for the following items not required: a small door-in-door (police door), shelves, and a fan. Provide a cabinet size of not less than 12 inches high by 10 inches wide by 6 inches deep. Provide cabinets designed for pole mounting with a 1-1/2 inch or larger conduit opening in the bottom. Include the following auxiliary equipment: on-off power switch with integral 20-ampere circuit breaker, lightning protection devices on incoming power lines, interference filters, terminal blocks, and a ground bus bar.

Provide materials in accordance with the City QPL.

733.06 Controller, Master, Traffic Responsive.

A. Description. The traffic responsive master controller consists of one component of a distributive processing, traffic responsive, control, and monitoring "closed loop" system. The master controller's principal operational task consists of selecting and implementing traffic signal timing plans in response to both actual traffic conditions or time based events. The master controller monitors, in real time, local intersection activity, and overall system performance.

The City typically locates the master controller in a local intersection cabinet. The master controller has the capability of uploading/downloading information to local intersection controllers.

B. Functional Requirements.

1. Design. Provide a solid state, digital microprocessor master controller design. Provide a controller using menu driven prompts.

Provide a master controller having an RS-232 port for connection to a laptop computer or printer. Provide software and connector cables for communication with a laptop.

2. Local Controllers. Provide each master controller capable of supervising and communicating with at least 24 local intersection controllers.

3. System Detectors. Provide each master controller capable of analyzing traffic sensor data from at least 32 system detectors. Distribute system detectors up to eight per intersection, but do not exceed the total system sensor capacity.

Provide the detectors assignable to each of the computational channels in each group, with the channels representing cycle selection, directionality (offset), non-arterial flow (split), and special congestion indicators of queue or occupancy.

Provide a master controller capable of monitoring and detecting system detector failure and removing failed detectors from volume and occupancy calculations. Upon resumption of satisfactory sensor operation, design sensors to automatically resume input to volume and occupancy calculations.

4. Timing Patterns. Provide each master controller with a minimum of 16 selectable patterns. Design each pattern to consist of a combination of cycle, offset, and split numbers for each intersection in the system.

Provide a master controller capable of implementing a "free" mode allowing all intersection controllers to operate without system coordination and a "flash" mode allowing all intersection controllers to operate in a flashing operation.

5. Operational Modes. Provide each master controller with the capability to operate in the following modes of operational control:

a. Traffic responsive mode; pattern selection based on dynamic traffic conditions as measured by system sensors located in the control area. As a minimum, base the pattern selection on the quantitative traffic flow parameters of volume, occupancy, and directionality of the arterial traffic.

Base transfer of patterns on programmable threshold values. Provide system sensors capable of selective weighting.

b. Time of day/day of week (time base) mode; pattern selection based on a preprogrammed event scheduler with automatic adjustments for seasonal daylight savings time changes. Provide this mode of operation with capability to call or override traffic responsive mode.

c. Manual override mode; pattern selection made by operator control at the master controller site.

Select the system coordination control for each master controller on a priority basis. Choose the priority from highest to lowest as follows:

a. Manual control entry or remote command

b. Time base control

c. Traffic responsive control

6. Reports. Provide each master controller with the capability to monitor and format intersection and system information for immediate output or for storage for a minimum period of 48 hours. As a minimum, generate the following types of reports:

a. A local intersection activity log showing the time, date and activity of all monitored local intersection failure conditions.

b. A system sensor failure log including time, sensor location, and type of failure.

c. A system log with pattern changes.

d. A system sensor data log including volume and occupancy for all system sensors.

7. Alarms. Provide each master controller with capability to continuously monitor intersection and system information for various systems and user defined critical conditions. Upon detection of an alarm condition, design the master controller to attempt to transmit alarm information to a preprogrammed telephone number. In case of failure to connect to the central software, design the master controller to continue to periodically retry reporting.

8. Communications. Provide a master controller supporting two-way dial-up communications for control, monitoring, data collection, and for timing pattern updating purposes. Provide a master controller including any communication devices or modems necessary to interface with the local intersection controllers within its control area.

9. Security. Provide a master controller with a user specified security code before altering any data. To view any parameter, do not require a security code entry. Provide a master controller capable of disabling security code requirements, allowing for perpetual access without requiring hardware changes.

733.09 Uninterruptible Power Supply (UPS).

A. Operation. In addition to the material requirements below, provide a UPS system with a minimum two and one half (2.5) hours of full run-time operation for an "LED-only" intersection with 1000 watts of active output power.

Provide a UPS compatible with all of the following traffic signal equipment; NEMA TS-1 cabinets and Type TS-2/A2 controllers.

Provide for the maximum transfer time, from disruption of normal utility line voltage to stabilized inverter line voltage from batteries, of 65 milliseconds or less. Apply the same maximum allowable transfer time when switching from inverter line voltage to utility line voltage.

Include a means to switch the intersection from full-operation to flashing operation after 2-hours of run-time, for the purpose of conserving battery operation during an extended utility power outage.

Include standard form C relay contacts to trigger an alarm within the controller assembly, informing a technician the system operates on battery backup.

Design for an operating temperature for both the inverter/charger, power transfer relay and manual bypass switch of -35 °F to +165 °F.

Use the power transfer relays and manual bypass switches rated at 240VAC/30 amps, minimum.

Provide a UPS capable of bypassing the utility line power whenever the utility line voltage is outside the following voltage range: 100VAC to 130 VAC, + 2 VAC.

When utilizing battery power, design the UPS output voltage between 110 VAC and 125 VAC, pure sine wave output, 60Hz ± 3Hz.

After restoration of utility line power between 100 VAC and 130 VAC for more than 30 seconds, design the UPS to dropout of battery backup mode and return to utility line mode.

In the event of inverter/charger failure, battery failure or complete battery discharge, provide the power transfer relay with the capability to revert to the NC (and energized) state, for cabinets connected to utility line power.

Do not exceed 10 hours to recharge the battery, from "protective low-cutoff" to 80% or more of full battery charge capacity.

Include all necessary wiring and hardware for mounting (shelf angles, rack, etc).

Furnish a UPS with available buck/boost mode operation, with a minimum input voltage range of 85 to 150 vrms. The unit display shall indicate when buck/boost mode is engaged. Default buck/boost setpoints shall be 108 vrms and 132 vrms unless specified otherwise in the Plans.

Furnish a UPS with an Ethernet port for remote monitoring and control. Provide interface software unless the Ethernet port has built-in web browser compatibility. Remote communication shall have the ability to make setting changes, review status, retrieve alarm and event logging that is time and date stamped for up to 50 events. The logs shall be printable.

Ensure the UPS cabinet has a mastic tape, neoprene foam, or silicone weather-resistant seal between the cabinet bottom flange and the concrete foundation. Minimum tape thickness shall be 1/8-inch and the tape shall be continuous with no gaps between tape pieces or between cabinet and foundation. Sealing tape shall completely cover the bottom cabinet flange and shall be rated for a temperature range of at least -30 °F to +140° F.

The UPS output notifications for on battery, battery 2 hour timer and low battery shall be wired into the traffic signal back panel to provide special status alarms for each output into the signal controller.

This item shall include a red LED status indicator lamp to allow maintenance personnel and law enforcement to quickly assess whether a traffic signal cabinet is being powered by a UPS. The LED housing shall be NEMA 4X, IP65 or IR66, rated for outdoor use and be tamper/shatter

resistant. It shall be a domed enclosure contained a red lens with LED that is visible from 100 foot minimum. The enclosure and LED lamp unit should be placed and centered on the top surface of the UPS cabinet and sealed from water intrusion. It should be wired using minimum 20 GA stranded, insulated hookup wire to the status relay outputs of the UPS.

The wires shall be terminated by lugs at the display end and permanently labeled "Backup Power Status Display," with wire polarity indicated. The red LED shall only illuminate to indicate the cabinet is operating under UPS backup power (the "backup" operating condition). This item also includes programming the UPS status relay outputs to produce the lamp status displays. These status displays will be solid 100% duty cycle (not flashing) displays. The operating voltage of the LED lamp shall be 120V AC unless otherwise indicated.

B. Maintenance, Displays, Controls and Diagnostics. Provide a UPS with a backlit LCD display that includes an event counter, hour meter, line and battery voltages/percentages and fault status. Provide the LCD display with touch keys for changing display statuses and to reset counters, hour meter date and time.

Provide a UPS with lightning surge protection compliant with IEEE/ANSI C.62.41.

Provide two (2) sets of equipment lists, operation and maintenance manuals, and board-level schematic and wiring diagrams of the UPS, and the battery data sheets. Provide a manual conforming to TEES 1999, Chapter 1 Section 1.2.4.2.

C. Battery System. Supply a minimum of four (4) batteries with the UPS system. Use 12VDC batteries rated at a minimum of 105 Ahrs, 20-hour discharge rate to 1.8 volts/cell at 77 degrees Fahrenheit, to achieve the 2.5 hour run time requirement. Provide batteries easily replaced and commercially available off the shelf.

Provide deep cycle, sealed prismatic lead-calcium based AGM/VRLA (Absorbed Glass Mat/ Valve Regulated Lead Acid) batteries.

Provide batteries certified in writing by the manufacturer to operate over a temperature range of -13 °F to +165 °F.

Place all batteries on battery heater mats in the enclosure, designed to extend the life of the batteries.

Design an integral system to prevent the battery from destructive discharge and overcharge. Do not allow batteries to recharge when battery temperature exceeds 122°F±5°F.

D. Enclosure. Provide an enclosure mountable to a standard Model 332, NEMA TS-1 or TS-2 traffic signal cabinet constructed of natural unpainted aluminum. Provide a cabinet size adequate to house “all” the UPS equipment including the controller unit, manual bypass switch, and the (4) batteries. Key the enclosure to the City of Columbus master #2 lock (1R 6380) and include 2 keys.

Provide a base seal for use between the enclosure to the concrete foundation or riser of continuous tape gasket material, minimum 1/8-inch thickness. Completely seal the interface to the adjacent controller cabinet with silicone caulk.

Provide an enclosure with a vent, fan and thermostat as per TEES Chapter 7, Section 2-Housings.

E. Warranty. Provide a two (2) year factory-repair warranty for parts and labor on the UPS from date of acceptance. Warrant batteries for full replacement for two (2) years from date of purchase.

Provide materials in accordance with the City QPL.

733.10 Foundations. For cabinet and pedestal foundations, use steel anchor bolts conforming to ASTM F1554, Grade 55 and galvanized in accordance with 711.02. Provide galvanizing extending at least 2 inches beyond the threads. Provide bent ends or a drilled and tapped steel plate as shown on the Plans.

ITEM 740 PAVEMENT MARKING MATERIAL

740.01 General.
740.02 Traffic Paint.
740.04 Thermoplastic Pavement Marking.
740.05 Preformed Pavement Marking.
740.06 Work Zone Pavement Marking.
740.07 Epoxy Pavement Marking Material.
740.08 Heat-Fused Preformed Plastic Pavement Marking Material.
740.09 Glass Beads.
740.10 Spray Thermoplastic Pavement Marking.
740.11 Contrast Markings.

740.01 General. Use permanent pavement marking materials meeting the requirements of this specification and passing the service test required by ODOT Supplement 1047 included on the City QPL maintained by the Laboratory. The Laboratory may retest pavement marking materials pre-qualified by a service test to determine formulation compliance to pre-qualified material and compliance with physical properties specified in this section. Submit certified test data and samples to the Laboratory. The City will consider failure of testing or certified test data to show formulation conforming to pre-qualified material or compliance with specified physical properties as cause for removal of the material from the City QPL.

Deliver the marking material in containers clearly marked to indicate the number of gallons, weight or size of material, material density (weight per unit volume), material color, batch number or other similar manufacturer’s identification, date of production, and the company name and address.

740.02 Traffic Paint. Provide white and yellow ready-mixed traffic paint suitable for marking various types of pavement. Provide paint capable of binding with glass beads in accordance with 740.09 Type A, on pavement exposed to traffic. Furnish paint that will not deteriorate in storage, within one year after date of receipt, to the extent that it cannot be readily broken up with a paddle to a smooth uniform paint capable of easy application by spray.

Provide paint capable of not bleeding or discoloring when sprayed on asphalt concrete surfaces.

Type 1 paint - the fast dry, water-based, 100 percent acrylic type.

Type 1A paint - fast dry, water-based, 100 percent acrylic type, used for cold weather applications.

Ensure that Type 1 and Type 1A paint conforms to the following requirements:

Property	**Test Method**	**Requirements** (Applies to both White and Yellow, unless noted)
Total Solids	ASTM D2369	70% minimum by weight
		58% minimum by volume
Titanium Dioxide, rutile type II	ASTM D1394	1 lb/gal minimum, White 0.2 lb/gal minimum, Yellow
Pigment % by Weight	ASTM D3723	+/- 2% of qualifying sample
Weight per Gallon	ASTM D1475	+/- 0.3 lb/gal of qualifying sample
Color	ODOT Supplement 1047	Appendix A
Viscosity (krebs units)	ASTM D562	70 minimum and 95 maximum @ 77 °F
Lab Drying Time	ASTM D711	10 minutes max. @ 77 °F, 50% RH 12 minutes max. @ 50 °F, 50% RH 14 minutes max. @ 35 °F, 50% RH

Prequalify materials in accordance with ODOT Supplement 1047. Use materials certified in accordance with ODOT Supplement 1089. Furnish materials according to the ODOT's Approved List.

740.04 Thermoplastic Pavement Marking. Provide thermoplastic pavement marking material formulated expressly for use as retroreflective pavement markings on asphalt concrete or Portland cement concrete pavement. Provide material that includes a mixture of Alkyd resins-19% minimum by weight with at least one resin that remains solid at room temperature, and contains premixed glass beads 740.09 Type C, 30% minimum by weight, with a 1.50 minimum index of refraction. Ensure that the ingredients are well mixed so that all parts are evenly dispersed throughout. Do not allow any foreign objects, skins, dirt, or such ingredients in the mix that would cause staining, discoloration, or bleeding. Provide suitable materials for application in molten form by the extrusion method. Provide material capable of retaining reflective glass beads after application, in accordance with 740.09 Type C.

A. Specific Gravity. Provide thermoplastic compound having a specific gravity of 1.6 to 2.3 at 77 °F ASTM D 792.

B. Flowability. Meet percent residue requirements in accordance with the following requirements:

1. AASHTO M 249, Section 4.3.6 and
2. AASHTO M 249, Section 4.3.8

C. Drying Time. AASHTO M249, Section 4.3.2.

D. Field Placement Stability. Provide material that, after proper application and drying time, does not tack and does not have an appreciable deformation or discoloration when subjected to typical vehicular traffic in air or road temperatures between -30 and 140 °F. Provide material capable of forming markings of a constant cross-section with a uniform density and character. Provide markings that maintain their original shape and pavement position.

E. Ring and ball Softening Point. Provide a material with a softening point of not less than 190 °F when tested in accordance with ASTM E 28.

F. Impact Resistance. AASHTO M 249, Section 4.3.4

G. Pigment Content. Provide yellow material containing a minimum of 5 percent by weight of primary yellow (lead chromate) pigment (or a lead free pigment) (measured according to ASTM D 126 or City approved lab method). Provide white material containing a minimum of 10 percent Titanium Dioxide-Rutile Type -2 by weight of white pigment.

H. Color.

	Minimum	Maximum
a. White, Daylight Directional Reflectance, ASTM E 1347	75	--
b. Yellow 1. Refer to Highway Yellow Color Tolerance Chart PR Color No. 1, June, 1965 U.S. Dept. of Transportation, FHWA: Yellow, Color Difference 595-13538, ASTM D 2244	50	--
Measure E, L, a, b as Cielab, Source "C"		
L	+0.75	+1.0
a	+0.9	+1.7
b	+4.4	+5.1

I. Yellowness Index, AASHTO M 249, Section 4.3.7

Prequalify materials in accordance with ODOT Supplement 1047. Use materials certified in accordance with ODOT Supplement 1089. Furnish materials according to the ODOT's Approved List.

740.05 Preformed Pavement Marking. Provide the preformed material suitable for retroreflective pavement markings on asphalt concrete or portland cement concrete pavement. Provide material free of cracks and having straight, true, and unbroken edges. Use flexible, formable material suitable for application with an adhesive without heating. Provide material containing glass beads uniformly distributed throughout with a 1.50 minimum index of refraction. Place a uniform surface layer of firmly bonded glass beads on the material to provide the initial minimum specific luminance values specified for the various types of material.

Provide material that resists deterioration by contact with highway deicing chemicals or because of the oil content of asphalt concrete pavement, or from oil droppings and other effects of traffic.

A. Type A1 Material. Provide Type A1 material conforming to ASTM D 4505, Level 1, Classes 2 or 3, and having a thickness of not less than 0.090 inch, including any pre-coated adhesive layer.

B. Type A2 Material. Provide Type A2 material conforming to ASTM D 4505, Level 1, Classes 2 or 3, and having a thickness of not less than 0.060 inch, including any pre-coated adhesive layer.

C. Type A3 Material. Provide Type A3 material conforming to ASTM D 4505, Level 1, Classes 2 or 3, skid resistance level A, and having a minimum thickness at the thinnest portion of the cross-section of not less than 0.020 inch, including any pre-coated adhesive layer.

Prequalify materials according to ODOT Supplement 1047. Furnish materials according to the ODOT's Approved List.

740.06 Work Zone Pavement Marking. Provide work zone pavement marking material conforming to ASTM D 4592, Type I (removable) or Type II (non-removable) with the following modifications:

A. Type I (removable): 0.030-inch minimum thickness.

B. Type II (non-removable): 0.015-inch minimum thickness.

Furnish materials according to the ODOT's Approved List.

740.07 Epoxy Pavement Marking Material. Provide material with a 100 percent solids two-part epoxy system capable of application at ambient temperature down to 50 °F. Provide a slow cure material capable of retaining reflective glass beads 740.09 Type D, after application.

Provide epoxy conforming to the following requirements:

A. Formulation. Provide epoxy formulated as a Long Life Pavement Marking System, capable of providing a minimum of 4 years of performance, free of any peroxides and any Tri-methyolpropane Tri-acrylate) TMPTA and other multi-functional monomers. Design the epoxy to provide simple volumetric mixing ratio of its components (such as 2:1).

B. Epoxide Number. Provide epoxy with an epoxide number of the epoxy resin conforming to the manufacturer's target value ±0.05 as determined by ASTM D 1652 for both white and yellow Part A on a pigment free basis.

C. Amine Number. Provide curing agent with the amine number of the curing agent (Part B) conforming to the manufacturer's target value ±50 as determined by ASTM D 2074 on a pigment free basis.

D. Laboratory Drying Time. Provide pavement marking material, when mixed in the proper ratio and applied at the properly prescribed wet film thickness at 75 ± 2 °F and with the proper saturation of glass beads, exhibiting a no tracking time of no greater than 40 to 45 minutes when tested in accordance with ASTM D 711.

E. Field Time to No-Track. Use pavement marking material providing a "no tracking condition" within 15 to 45 minutes. The Engineer will determine the "no tracking condition" by applying the markings and beads at the specification requirements to dry pavements at a low temperature of 45 °F and high temperature of 120 °F. Run tests at the manufacturer's highest and lowest recommended application humidity. Apply the marking materials at the manufacturer's recommended application temperature. The Engineer will determine the "no tracking" time by passing over the line with a passenger car at a speed of 25 to 35 mph in a simulated passing maneuver. The Engineer will consider a line showing no visual deposition of the material to the pavement surface when viewed at a distance of 50 ft as showing "no tracking" and conforming to this requirement for time to "no track". Protect the line from tracking during the setting period by coning off or as shown on the plans.

F. Field Curing. Provide epoxy pavement marking material capable of fully curing at a constant surface temperature of 45 °F or above.

G. Hardness. Provide epoxy pavement marking materials, when tested in accordance with ASTM D 2240, having a Shore D Hardness between 70 and 90. Allow samples to cure at room temperature 75 ± 2 °F for a minimum of 24 hours and a maximum of 72 hours before performing the indicated test.

H. Certified test data. Provide a material manufacturer's certified test data showing material compliance with the provisions of this section. A certification of compliance does not waive the requirements for a state inspection, sampling, or testing.

I. Infrared Spectra. Supply a copy of the infrared spectra of each component on each lot number.

J. Material Performance Qualifications. Verify the manufacturer's expertise and performance history including: completed and passed service tests in accordance with ODOT Supplement 1047; verifiable installations; ample production capacity; proper facility; compliance with EPA regulations; verifiable quality control program; and passed a minimum of 4 years of performance (durability and retroreflectivity) on concrete or asphalt surface in the State.

K. Condition in Container. Perform tests in accordance with Fed Std 141 No. 3011.2, Hand Stirring by Spatula, 5 minutes maximum.

Prequalify materials in accordance with ODOT Supplement 1047. Use materials certified in accordance with ODOT Supplement 1089. Furnish materials according to the ODOT's Approved List.

740.08 Heat-Fused Preformed Plastic Pavement Marking Material. Provide heat-fused preformed plastic pavement marking materials conforming to the following Type B, Post-heated tape:

Type B90 - 90 mil thickness

Type B125 - 125 mil thickness

Glass beads..... 740.09

Prequalify materials according to ODOT Supplement 1047. Furnish materials according to the ODOT's Approved List.

740.09 Glass Beads. Furnish the City certified test data of the arsenic and lead content of the glass beads. Glass beads shall contain no more than 200 parts per million of arsenic or lead as determined in accordance with Environmental Protection Agency testing methods 3052, 6010B, or 6010C, according to SEC 1504 STANDARDS. Section 109 of title 23, United States Code, (r) Pavement Markings.

A. Type A. Provide Type A glass beads for traffic paint conforming to ODOT Supplement 1008 and to AASHTO M 247, Type 1 without flotation properties, but dual coated (for moisture resistance and adhesion), with the following exception: 4.6 Flotation Test.

Package the glass beads for traffic paint in bags designated "740.02". Use materials certified according to ODOT Supplement 1089.

B. Type C. Provide Type C glass beads for thermoplastic material conforming to ODOT Supplement 1008 and meeting the following requirements:

Sieve Size	Percent Retained		
No. 16	3 maximum	**Refractive Index**	1.50 to 1.60
No. 20	5 to 20	**Roundness**	80 minimum
No. 40	65 to 95	**Coating**	Moisture resistant (for drop-on beads only)
No. 50	0 to 5		

Clearly mark the glass bead packaging "THERMO".

Use materials certified in accordance with ODOT Supplement 1089.

C. Type D. Furnish Type D glass beads for Epoxy Pavement Marking conforming to ODOT Supplement 1008.

Clearly indicate EPOXY - SIZE I or EPOXY SIZE II on the glass bead packaging.

Provide glass beads having the following gradation when tested in accordance with ODOT Supplement 1089.

SIZE I		SIZE II	
Sieve Size	**Percent Retained**	**Sieve Size**	**Percent Retained**
No. 10	0	No. 20	0 to 5
No. 12	0 to 5	No. 30	5 to 20
No. 14	5 to 20	No. 50	30 to 75
No. 16	40 to 80	No. 80	9 to 32
No. 18	10 to 40	No. 100	0 to 5
No. 20	0 to 5	Pan	0 to 2
Pan	0 to 2		

Reflective Media: Provide smooth, clear glass beads free from any air inclusions, and scratches affecting their functions as a retro-reflective media, and having the characteristics listed below.

Roundness (Percent by Weight): Provide beads with not more than 20 percent of the glass beads irregular or fused spheroids and with at least 80 percent of the beads true beads.

Index of Refraction: Provide beads with a refractive index of a minimum of 1.50 as determined by the liquid immersion method at 77 °F. Provide beads with a silica content of glass beads not less than 60 percent.

Coating: Provide Size I glass beads coated with a silane-type adherence coating to enhance its embedment in, and adherence to the applied binder film. Provide coated beads emitting a yellow-green fluorescence when tested by the Dansyl Chloride test procedure. Provide Size II glass beads treated with a moisture-proof coating. Provide both types of glass beads showing no tendency to absorb moisture in storage and remaining free of clusters and lumps. Ensure that the beads flow freely from the dispensing equipment at any time when surface and atmosphere conditions are satisfactory for marking operations.

Determine the moisture-resistance of the glass beads on the basis of AASHTO T 346 section 9.

Use materials certified in accordance with ODOT Supplement 1089.

740.10 Spray Thermoplastic Pavement Marking. Provide spray thermoplastic pavement marking material specially formulated for use as retroreflective pavement markings on asphalt concrete or Portland cement concrete pavement. Provide material that includes a mixture of resins with at least one resin that remains solid at room temperature, and contains uncoated premixed glass beads, in accordance with 740.09 Type C. Mix the ingredients well to evenly disperse all parts throughout the mix. Remove foreign objects, skins, dirt, or such ingredients that would cause staining, discoloration, or bleeding. Provide suitable materials for spray application in molten form. Provide material capable of retaining drop on reflective glass beads, in accordance with 740.09 Type C, after application.

A. Composition.

	White	**Yellow**
Binder	25% Min.	25% Min.
TiO2 Pigment (Type II Rutile)	10% Min.	
Lead-Free Pigment (Yellow 83)	N/A	*
or Leaded Pigment (Yellow 83)	N/A	**
Inter mixed Glass Beads	30% Min. (by weight)	30% Min. (by weight)
Filler	35% Max.	42% Max.

* Amount of lead-free pigment is at the discretion of the manufacturer, as long as all other compositional requirements are met

** Furnish yellow material containing a minimum of 5 percent by weight of primary yellow (lead chromate) pigment (measured as per ASTM D 126 or City approved lab method)"

B. Binder. Provide alkyd-based binder consisting of a mixture of synthetic resins with at least one resin that remains solid at room temperature, and high boiling plasticizers. Provide at least one-third of the binder composition as maleic modified glycerol ester of rosin, consisting of no less than 8 percent by weight of the entire material formulation.

C. Pigment. Provide titanium dioxide pigment of a Rutile type with a minimum purity of 92%.

Use lead-free Pigment Yellow 83 produced to meet the requirements of FED 595 Color No. 13538.

D. Filler. Ensure filler to be incorporated with the resins is a white calcium carbonate, silica, or any approved substitute. Ensure that any filler, which is insoluble in 6N hydrochloric acid, passes a No. 100 sieve.

E. Color. Provide pure white spray thermoplastic, free from any tint with a minimum daylight reflectance (Y) of 75. Do not exceed the yellowness index of 0.15 when tested in accordance with ASTM D4960 and E313.

Visually match yellow spray thermoplastic with FED 595 Color No. 13538. Provide a daytime reflectance (Y) greater than 45.

Ensure white and yellow colors fall within the chromaticity coordinates of the color box in Appendix A of ODOT Supplement 1047.

G. Specific Gravity. Provide spray thermoplastic material having a specific gravity of 1.85-2.15.

H. Softening Point. After heating the marking compound for 4 hours ± 5 min. at 375ºF ± 3ºF and testing in accordance with ASTM E28, verify a minimum softening point of 180ºF as measured by the ring and ball method.

I. Bond Strength. After heating the marking compound for 4 hours ± 5 min. at 375ºF ± 3ºF, verify the tensile bond strength exceeds 180 psi when tested in accordance with ASTM D4796.

J. Impact Resistance. After heating the marking compound for 4 hours ± 5 min. at 375ºF ± 3ºF, verify a minimum impact resistance of 50 inch pounds when tested in accordance with ASTM D2794. Verify no cracks or bond loss occur when making a 0.0625 inch thick film drawdown at 375ºF ± 3ºF on an unprimed sandblasted Portland cement concrete block. Test sample with a 5/8-inch male indentor and no female Die, at room temperature.

K. Indentation Resistance. When tested according to ASTM D 2240 using a Shore Durometer, Type A2, with a 2.2 pound load, ensure hardness between 5 and 30 after 15 seconds of contact with the sample. Ensure a durometer and sample at 113ºF ± 3ºF.

Prequalify materials according to ODOT Supplement 1047. Use materials that follow the requirements of ODOT Supplement 1089.

740.11 Contrast Markings. The 1.5 inch black contrast border shall be used on ALL arrows, symbols and words and on white longitudinal lines as shown in Table-1 that are placed on and/or grooved in Portland Concrete surfaces and/or any markings a directed per the Engineer. Contrast

markings shall be non-reflective high skid resistant* preformed thermoplastic pavement marking material that is heat applied and will create a shadow effect when applied to pavement markings when located on a Portland concrete surface. The surface of the material must provide a minimum resistance value of 50 BPN (British Pendulum Number) as tested by the British Portable Skid Tester, in accordance with ASTM E303-93. Heat applied preformed pavement marking materials shall comply with section Item 645, Item 647, 740.05, and 740.08 for Type B90, 90 mil thickness material. The heat applied preformed pavement marking materials shall be applied to the roadway surface by the use of normal heat of a propane torch. Prepare surfaces and apply recommended primer and/or adhesive according to the manufactures' recommendations. The material shall be capable of conforming to pavement contours, breaks or faults through the action of traffic at normal pavement temperatures. The markings shall have the resealing characteristics, such that is capable of fusing with itself and previously applied thermoplastic when heated with the torch. No discoloration of the preformed material shall be evident 48 hours after the initial installation.

Application of the material may be made with the ambient air temperatures down to 32 degrees F. The thermoplastic material must conform to AASHTO designation M249-98 (2003), latest revision with the exception of the relevant differences due to material being supplied in a preformed state and non-reflective.

After proper installation, all pavement markings shall be immediately ready for traffic. They shall not require any additional period of time to cure, set, or otherwise become ready for traffic or inclement weather beyond a standard installation process. When subjected to traffic and/or inclement weather immediately after proper installation, markings shall not incur damage, loss of adhesion, or reduction in any performance characteristic.

Use black pavement markings, without drop-on glass beads, that visually match the color chips that correspond to the Federal Test Standard Number 595a. Use markings that when subjected to accelerated weathering as described in U.S. Federal Specification No. (TT-P-115F) are within the tolerance limits of the color chip, BLACK #37038.

800 WATER SUPPLY & DISTRIBUTION

ITEM 801 FURNISHING AND LAYING PIPE AND FITTINGS

801.01 Description
801.02 Design Criteria
801.03 Ductile Iron Pipe
801.04 Fittings for Use with Ductile Iron Pipe
801.05 Concrete Pipe and Fittings
801.06 Steel Pipe and Fittings
801.07 Joints for Ductile Iron Pipe
801.08 Joints for Steel and Concrete Pipe
801.09 Water Mains Appurtenances
801.10 Excavation and Pipe Installation
801.11 Backfill within the Influence of Pavement
801.12 Backfill Outside the Influence of Pavement
801.13 Water Main Cleaning and Flushing
801.14 Hydrostatic Tests
801.15 Chlorination of Completed Pipe Line
801.16 Main Shuts
801.17 Certification
801.18 Method of Measurement
801.19 Basis of Payment

801.01 Description. The work in this section consists of all work for the furnishing and laying of the various sizes of water mains. This work comprises excavating the trench, furnishing and laying pipe in the trench and jointing it, placement of concrete thrust blocks, back-filling the trench, repairing or replacing head walls, drains, sewer, gas, electric and water connections, and any other structures or facilities disturbed or damaged by the Contractor's operations; disposing of and hauling away excavated material; testing; and any work needed to assist the City's effort in chlorinating the water main; and all other work required for the furnishing and laying of the pipe lines and connections complete and ready for service as shown on the plans and covered in the specifications. Provide and install of all required fittings including bends, reducers, polyethylene encasement, bitumastic paint, petrolatum-based tape coating, wax tape coating, blow-offs, tees, sleeves, chlorination taps, small diameter branch connections; connections at the ends of mains to other lines or fittings, and special castings required for the installation of the valves, all as called for on the drawings. For installations involving large diameter water mains (20-inch and larger), the Contractor shall coordinate with the pipe manufacturer to have a representative from the manufacturer provide an on-site meeting with the pipe crews, prior to pipe installation, that outlines the major components of the pipe installation.

Contractor Qualifications. The City will only allow Contractors holding either a City of Columbus Water Contractor's License or a Combined Water/Sewer Contractor's License in accordance with Columbus City Code 1103.02 and 1103.06 to perform work on City of Columbus water main, including water service lines and taps.

801.02 Design Criteria. Provide pipe designed to meet the following:

1. **Reference Standards.**
   - A. Ductile Iron – AWWA C150, Manual M41
   - B. Concrete – AWWA C301, Manual M9
   - C. Steel – AWWA C200, C206, Manual M11
2. **Manufacturer's Qualifications:**
   - A. No less than five (5) years successful experience manufacturing proposed pipe material, pipe diameter, and pipe joint with an ISO 9007:2000 or other equivalent nationally recognized, certified quality assurance program.
   - B. Use only one type of pipe material where the City allows material alternates. When adjoining proposed water main to existing water main of different pipe material and/or coating, provide approved connection with necessary adapters. Ensure that type of pipe selected and resulting methods and means complies with requirements and limitations set forth herein and on the Plans.
3. **External Loads.**
   - A. Dead Loads: 8 feet of cover or 2.5 feet of cover whichever produces greatest load in conjunction with live load.
   - B. Live Loads: AASHTO HS-20 truck, AREMA E-80 loads for railroad crossings. Use 1.5 Impact Factor.
   - C. Soil Unit Weight: minimum 120 pcf.
   - D. Design pipes with Marston's earth loads for transition width trench for all heights of cover.
   - E. Exclude structural benefits associated with primary liner in design of pipe in tunnel installations.
4. **Internal Pressure.**

A. 150 psi normal operating pressure

B. 100 psi surge allowance (water hammer)

C. 150 psi test pressure.

D. Minimum pressure: full vacuum

5. **Laying Condition.**

A. For 16"diameter pipe and under: Flat-Bottom trench with bell holes.

B For 20" diameter pipe and greater: 6" bedding

C. No blocks

D. Tamped backfill

E. 1.2 Load factor for Concrete pipe

6. **Thrust Restraint Lengths:**

A. For pipe diameters 20-inch and greater, obtain calculations performed by the pipe manufacturer to determine adequate thrust restraint lengths in accordance with referenced standards. Do not include passive resistance of soil. Establish restrained joint lengths based on the appropriate pipe material using AWWA M9, M11, or M41, latest edition. When anticipating a high water table or submerged conditions, include buoyancy conditions for soil unit weight. Submit calculations sealed by a registered Professional Engineer for review by City. Adjustments in deflections or use of other pipe material may result in reduction or increase of thrust lengths. Adjustments in restrained length will result in no additional cost to City.

7. **Factory Hydrostatic Test**

A. Ductile Iron Pipe: AWWA C 151, Section 5.2.1; Concrete Pipe: AWWA C 301, Section 4.6.4.3; Steel Pipe: AWWA C 200, Section 5.2; at point of manufacture. The City will either reject pipe revealing leaks or cracks or require repairs.

8. **Design Plans:**

A. Pipe diameter shown on the Plans refers to the inside diameter of the pipe after lining. Unless otherwise noted, the Plans detail ductile iron pipe. If the Plans show concrete or steel pipe, furnish equivalent fittings or a combination of fittings to match those specified or shown. Submit methods for tying pipe joints, anchorage and special backing to Engineer for approval before installation.

B. The City may not necessarily call out bevel pipe, outlet connections on straight pipe, closure pipe assemblies and other accessories required for steel or concrete pipe on the Plans. Furnish as required to satisfactorily install the new water main as shown on the Plans. Include payment for these piping items in the unit price bid for Item 801.

C. Prior to start of work, provide the Engineer a laying schedule, including laying dimensions and pipe calculations for 20" and greater diameter pipe. The Engineer may require a pictorial layout. Provide a complete and accurate laying schedule conforming to the Plans. For 20" and greater diameter pipe, stock additional bevel adapters and short lengths of pipe at the job site to permit field adjustment of the alignment. The unit price bid of Item 801 includes payment for these items.

9. **Pipe Identification:**

A. Stamp, mark, or identify all water main materials with following: name of manufacturer, date of manufacture, operating design pressure, and manufacturer's part number. Provide markings on the outside of the pipe.

10. **Corrosion Protection:**

A. For all exposed portions of nuts and bolts, such as flanged or mechanical joints, coat with bitumastic paint, petrolatum-based tape coating system, or wax-tape coating system as approved in the current Division of Water Approved Materials List.

B. For 20" diameter and greater pipe, bond gasketed and flanged joints with bonding clips or wires to provide electrical continuity along entire pipeline. Provide bonding clips for Concrete Pipe. Provide bonding wires for Ductile Iron Pipe. Provide either bonding clips or wires for steel pipe.

1. Electrical Bond Wires: Use electrical a minimum No. 2 AWG, seven strand, copper cable with THWN insulation for bond wires. Remove one inch of THWN insulation from each end of the bond wire. Provide a minimum of two bond wires. Attach wires to pipe by thermite welding. Include a continuity verification of the water main.

   Furnish weld caps of high density plastic, 10 mils (minimum) thickness as included in the current Approved Materials List. Provide caps that incorporate a dome for the weld, a tunnel to contain the lead wire from the weld connection, and a base plate to cover the prepared pipe surface. Provide weld caps prefilled with mastic/adhesive with an integral primer for adhesion to the pipe or structure. Size weld caps for the thermite connection. Coat any damaged area of the pipe exposed after application of the weld cap with bitumastic paint.

2. Electrical Bond Clip: Weld three (3) ASTM 366 steel bonding clips, each approximately 0.13 inches thick, 2.5 inches long, and 1.25 inches wide, with 1/8-inch fillet welds to the bell and spigot of adjacent concrete or steel pipe with rubber gasketed joints. Manufacture clips to maintain continuity regardless of small deflections of finished joints.

C. For 20" diameter and greater, provide flange isolation kits at valves for steel or concrete mains, connections to existing pipe, connections between dissimilar pipe materials, between the Tee and the Valve on Large Diameter Water Taps (3-inch and larger), or where shown on the Plans. Provide flanged end fittings/outlets, as necessary, to isolate large diameter water taps (3-inch and larger).

801.03 Ductile Iron Pipe. Provide pipe manufactured in accordance with AWWA C151 except as herein modified:

Corrosion Allowance: 0.08 inches minimum

Wall Thickness and Class as follows:

Size	Wall Thickness	Thickness/Pressure Class
3 Inches	0.31	53
4 Inches	0.29	52
6 Inches	0.31	52
8 Inches	0.33	52
10 Inches	0.35	52
12 Inches	0.37	52
16 Inches	0.40	52
20 Inches	0.33	250
24 Inches	0.37	250
30 Inches	0.42	250
36 Inches	0.47	250
42 Inches	0.52	250
48 Inches	0.58	250
54 Inches	0.65	250
60 Inches	0.68	250
64 Inches	0.72	250

Provide pipe with a bituminous coated cement lining complying with AWWA C104 Specifications and an outside coating of bitumastic enamel or approved equal.

Provide ductile iron pipe cast, cleaned, cement lined, coated, tested, and certified at a single manufacturing facility with all manufacturing units contiguous to one another.

Gauge full from the end of the spigot to two feet from the flare of the bell ten (10) percent of the ductile iron pipe supplied to the project.

The City will not allow field welding on ductile iron pipe or fittings, except for the bonding of joints, or outlets welded on in the factory unless otherwise approved by Engineer.

Restrain the water main joints using an approved restrained joint for all cased crossings.

Polyethylene Encasement: Wrap all ductile iron pipe with tube style 8-mil linear low density polyethylene (LLDPE) film made from virgin material (no recycle material) in accordance with AWWA C 105/A21.5. Provide black film with nominal 2% carbon black UV inhibitor and printed per the C105 Standard. Adhere to the following Physical Properties:

a. Tensile Strength: 3,600 psi minimum in machine and transverse direction (ASTM D882)

b. Elongation: 800% minimum in machine and transverse direction (ASTM D882) as measured using rubber lined grips.

c. Dielectric Strength: 800 Volts/Mil thickness, minimum (ASTM D149)

d. Impact Resistance: 600 grams, minimum (ASTM D1709 Method B)

e. Propagation Tear Resistance: 2,500 grams force, minimum in machine and transverse direction (ASTM D1922)

Testing: Virgin Polyethylene Encasement Film as delivered may undergo third party specification compliance testing by the City. The City will require the Contractor to reimburse the City for the cost of such test if the testing reveals non-virgin polyethylene encasement material and the material fails to meet the specifications. Additionally, the City will require the Contractor to immediately remove the non-compliant film from the site. Remove and replace pipe installed with non-compliant polyethylene encasement film at no additional cost to the City.

Installation: Deliver film to the jobsite contained in a sound sacrificial sleeve of UV Protected Polyethylene to protect contents during storage prior to installation.

Install the polyethylene encasement per Method A of ANSI/AWWA C105/A21.5. Remove all lumps of clay, mud, cinders, etc. from the pipe surface before encasing the pipe. Keep soil, or bedding material, from becoming trapped between the pipe and the polyethylene sleeve. When lifting polyethylene-encased pipe use a fabric type sling or padded cable to protect the polyethylene. Overlap joints (double coverage) and tape. Fold excess slack over the top of the pipe and tape in place every three feet. Carefully backfill the pipe according to 801.11 and 801.12. To avoid damage during backfilling allow adequate slack in the film tube at joints. Use backfill material free of cinders, rocks, boulders, nails, sticks or other material that could damage the polyethylene sleeve.

Appurtenances:

a. Cover Pipe Shaped appurtenances in the same manner as the pipe.

b. For odd-Shaped appurtenances, pass a split length of sleeve under the appurtenance and then over the appurtenance. Bring together around the body and securely tape into place. Make seams by folding edges over twice and taping.

c. Bolted Joints and Valves: Overlap joints as for pipe installation. Tape film securely around valve stems and other penetrations. Use care to prevent penetration of the film by bolts and other Protrusions.

d. Branches, Blow-offs, Air Valves, Taps: Wrap a minimum of three layers of tape completely around the polyethylene encased pipe to cover area where tapping machine will contact the pipe. Install the corporation stop directly through the tape and polyethylene. Repair any damage after the installation with tape or an additional wrap of polyethylene film. Wrap copper water tap at least three feet back from the installation with tape or additional polyethylene film to prevent electrolysis.

Tape: Provide 1- 1/2" minimum width, 6mil nominal thickness PVC Tape, Use to fit, anchor, or repair the encasement film.

801.04 Fittings for Use with Ductile Iron Pipe. Provide Class 250 fittings, manufactured in accordance with AWWA C110 or C153. For pipes 24-inches and larger, provide AWWA C153 Compact Ductile Iron Fittings. Provide fittings with ends made in accordance with AWWA C111. Coat all fittings inside and outside with a bituminous coating complying with AWWA C110 or C153. Provide factory-coated carbon steel bolts for mechanical joint fittings, and coat with bitumastic paint, wax-tape coating system, or petrolatum-based tape coating system as approved in the current Division of Water Approved Materials List.

801.05 Concrete Pipe and Fittings. The Contractor may use prestressed concrete cylinder pipe and fittings in sizes 20-inches or larger in diameter. Manufacture in accordance with AWWA C301.

Provide steel cylinder for fittings designed in conformance to AWWA Steel Pipe Manual, M11, (latest revision) so that allowable deflection of the pipe under combined dead and live loads does not exceed 2 percent of the internal diameter of the steel cylinder.

Design Criteria:

a. Use 90-degree Olander coefficients for earth and live loads and water weight contained in pipe along with 15-degree Olander coefficients for pipe weight.

b. Tunnel and Augered Sections: Provide constant outside diameter from bell to spigot end for pipe. Exclude structural benefits associated with primary liner. Design pipe and pipe joints to carry loads including but not limited to: overburden and lateral earth pressures, subsurface soil, grouting, other conditions of service, thrust of jacks, and stress anticipated during handling and installation.

Butt straps for closure piece: minimum 12-inch wide split butt-strap; minimum plate thickness equal to thinnest joined member; fabricated from material equal in physical and chemical properties of thinnest joined member. Provide minimum lap of 4 inches between joined member and edge of butt strap, welded both inside and outside. Provide minimum 6-inch welded outlet for inspecting each closure section. The City will not require a welded outlet for inspection when a closure section contains an access manway within 40 feet of the closure section.

Visible cracks: The City will not accept visible cracks longer than 6 inches, within 15 degrees of a line parallel to pipe longitudinal axis except:

a. In surface laitance of centrifugally cast concrete,

b. In sections of pipe with steel reinforcing collars or wrappers, or

c. Within 12 inches of pipe ends.

Repair interior lining cracks that exceed 1/16-inch (0.0625 inches) wide. The City will reject pipe with exterior coating cracks that exceed 0.01 inches wide. When pipe has irreparable cracks exceeding limitations, immediately remove pipe from site.

Field repair procedures for coatings/linings:

a. Areas less than or equal to 6 inches in diameter: Patch honeycomb and minor defects in concrete surfaces with non-shrink grout. Use only manual chisels to chip away mortar coating or lining. Cut out unsatisfactory material and replace with non-shrink grout, securely bonded to existing coating or lining. Finish junctures between patches and existing concrete as inconspicuous as possible. Strike off non-shrink grout flush with surrounding surface after the patch stiffens sufficiently to allow for greatest portion of shrinkage. Finish surface in accordance with lining requirements.

b. Do not use pipe with defective coating areas greater than 6 inches in diameter. Immediately remove pipe from project.

c. The City will reject pipe with a steel cylinder dented while making field repair. Immediately remove pipe from project.

801.06 Steel Pipe and Fittings.

Use steel for steel pipe and fittings in sizes 20-inches or larger in diameter that satisfies the minimums of ASTM A 36, ASTM A 570 Grade 36, ASTM A 53 Grade B, ASTM A 135 Grade B, or ASTM A 139 Grade B.

Provide pipe sections in length of no less than 10 feet except as required for special fittings and closure sections. Provide closure sections and short sections of steel pipe not less than 4 feet in length unless indicated on the Plans or specifically permitted by Engineer.

Design Criteria:

a. Maximum deflection from specified diameter: 3 percent for mortar lined and flexible coated pipe.

b. Modulus of soil reaction (E'): based on laying conditions in accordance with Table 6-1 of AWWA M 11, but no greater than 2,000 psi.

c. Deflection lag factor: (D1) = 1.2.

d. Bedding constant: (K) = 0.1.

e. Minimum diameter (D) over thickness (t) ratio = 230

Nominal Allowable Steel Wall Thickness: Provide pipe with a wall thickness not less than following table for depths of cover up to 16 feet. Provide pipe with a net internal diameter (including internal linings) less than net internal diameter listed. Provide pipe design calculations to confirm adequate wall thickness.

Net Inside Diameter (Inches)	Minimum Wall Thickness (Inches)
20, 24, and 30	0.149
36	0.178
42	0.207
48	0.235
54	0.271
60	0.301
66	0.333
72	0.362
78	0.393
84	0.423
90	0.454
96	0.484

The City will require a Cathodic Protection System in accordance with the Contract Documents.

Linings and Coatings: Provide shop-coated and shop-lined steel pipe with minimum of one coat of shop-applied primer approved for use in potable water on all exposed steel surfaces. Use primer with no less than 5 percent solids for field-applied coatings on tape-coated steel pipe. Provide primer compatible with coating system and in accordance with coating manufacturer's recommendations.

Shop-applied Cement-mortar Lining: AWWA C205; except as specified herein: 1/2 inch minimum thickness for pipe diameters 42-inches and larger; 3/8-inch minimum thickness for pipe diameters 36-inches and smaller. Cut back lining from joint ends to facilitate joining and welding of pipe. Apply cement-mortar lining to inside of pipe by centrifugally spinning. For special sections (shape of which precludes application by spinning method) accomplish by mechanical placement or pneumatic placement and finish to produce smooth, dense surface comparable to centrifugally spinning. Use galvanized wire mesh in accordance with AWWA C205 when not applying shop-applied mortar by machine. Do not extend wire mesh across welded portion of mitered fittings. Crimp mesh to provide integral "chair" so wire does not fully rest against steel cylinder. Make repairs of cement-mortar lining for widths exceeding 6-inches by bonding to steel and adjacent faces of lining with bonding agent conforming to ASTM C 881, Type II. Repair cracks 1/16 inch and larger to satisfaction of Engineer and according to AWWA C205.

External coating system for steel pipe installed above ground and in vaults (exposed):

A. Provide approved 3-coat epoxy/polyurethane coating system as designated below. Provide materials from same manufacturer.

1. Surface Preparation: SSPC SP 10, Near White Blast Clean, 2.0 to 3.0 mils surface profile.

2. Prime Coat: 4.0 to 4.0 mils DFT, Inhibitive Epoxy Primer, or approved equal.

3. Intermediate Coat: 4.0 to 6.0 mils DFT. Chemical Resistant Epoxy, or approved equal.

4. Finish Coat: 1.5 to 2.5 mils DFT Aliphatic Polyurethane, or approved equal

5. Total Allowable Dry Film Thickness for System: Minimum: 9.5 mils, Maximum: 12.5 mils.

B. Perform adhesion test on pipe in accordance with ASTM D 4541. Minimum field adhesion: 1,000 psi. Perform test on pipe for project at frequency of one for every 1000 square feet of coating. Perform cure test in accordance with ASTM D 4752 (solvent rub test) and ASTM D 3363 (pencil hardness) for each section of pipe. Repair tested areas with approved procedures.

External Coating Systems for Buried Steel Pipe: Supply pipe with one of the following coatings specified.

A. Tape Coating: Provide approved tape for external tape coating, applied in pipe manufacturer's facility. Apply in accordance with AWWA C214 and manufacturer's requirements; 80-mil. Components: Primer, one 20-mil layer of inner-layer tape for corrosion protection and two 30-mil layers of outer-layer tape for mechanical protection. Where using couplings, bond coupling to adjacent pipes with bonding cables as shown on the Plans or recommended by manufacturer. Use approved filler putty type insulating putty to fill in gap and create smooth sloped transition between top of reinforcing plate and pipe, before applying tape coating. Primer: Compatible with tape coating, supplied by coating-system manufacturer. Provide pipe with shop coatings cut back in accordance with manufacturer's recommendations to facilitate joining and welding of pipe. Do not expose tape coating to direct sunlight for more than 90 days. Discard (remove) and replace outer layer of tape coating when exposure exceeds 90 days at no additional cost to the City.

B. Polyurethane Coating: AWWA C222; shop-applied, polyurethane coating except as modified in this Section; Minimum DFT of 25 mils (0.025 inch). Coating thickness on sealing areas of spigot end of pipe exterior: minimum 8 mils (0.008 inch), maximum of 10 mils (0.010 inch). The City will allow the Contractor to exceed the 10 mils maximum in spigot end, provided the spigot diameter does not exceed the maximum specified by pipe manufacturer. Perform adhesion test on pipe in accordance with ASTM D 4541. Minimum field adhesion: 1,000 psi. Perform test on pipe for project at frequency of one for every 1,000 square feet of coating. Perform cure test in accordance with ASTM D 4752 (solvent rub test) and ASTM D 3363 (pencil hardness) for each section of pipe. Repair tested areas with approved procedures.

External Coating System for Steel Pipe in Tunnel, Casing: For water mains in tunnel where using annular grout, shop prime external surfaces of steel pipe with 4.0 to 6.0 mils DFT of approved Inhibited Epoxy Primer.

Inspection and testing of coatings (factory): Perform electrical inspection on inner layer of tape before applying intermediate layer of tape, and in accordance with NACE Standard RP-02-74. Perform electrical holiday test with 60-cycle current audio detector, in accordance with AWWA C214.

Repair detected holidays immediately before applying outer layer of tape. Clear holiday area of material and reprime if necessary. Recoat area with inner wrap tape. Overlap inner wrap tape onto surrounding inner wrap coating by at least 2-inches. Perform electrical retest at repaired area after repairing holiday, and before continuing outer wrap.

Inspection and testing of coatings (field): Perform "spot check" of external coatings, and repair per manufacturer's recommendations. Shrink Wrap: Perform "spot-check" electrical inspection on shrink wrap to check for holidays, as directed by Engineer in field. Perform peel tests over heat affected zone. Minimum acceptable result: 15 lbs-ft/in.

Field repair procedures and special fittings application for cement mortar lining:

a. Areas less than or equal to 6-inches in diameter: Patch honeycomb and minor defects in mortar surfaces with non-shrink grout. Repair defects by cutting out unsatisfactory material and replacing with non-shrink grout, securely bonded to existing mortar. Finish to make junctures between patches and existing mortar as inconspicuous as possible. After each patch sufficiently stiffens allowing for greatest portion of shrinkage, strike off grout flush with surrounding surface.

b. Areas greater than 6-inches in diameter: Remove defective lining down to bare steel by chipping, taking sure care to prevent further lining damage. Leave the ends of lining where removing defective lining, square and uniform, not feathered. Clean bare steel with wire brush to remove loose or other foreign matter. Remove existing wire reinforcement and replace. Overlap new reinforcement to existing reinforcement by 1/2 inch. Secure reinforcement, against wall of pipe, at frequent intervals, by tack welding to pipe. Prepare cement mortar mixture. Mixture to compose of Portland Type II cement, sand, and water. Proportions of sand to cement not to exceed 3 parts sand to 1 part cement, by weight. Use only enough water to obtain proper placement characteristics. Discard mixture when Set-up time exceeds 1/2 hour. The Contractor may also use non-shrink grout. Do not use combination of cement mortar and non-shrink grout within same repair. Apply an approved concrete bonding agent; refer to the Division of Water Approved Materials List, to bare steel and interface of existing lining. After applying bonding agent to steel and lining, apply new mix within 10 minutes. Apply cement mortar to repair area 1/2 inch thick, then hand trowel to achieve smooth dense finish, making sure not to leave exposed wire. To ensure proper thickness while placing new mortar, check thickness with 1/2-inch-long wire gauge. Curing: Place plastic sheeting over repair area; use tape to adhere plastic to area surrounding repair area. Let cure for 4 days, and then remove plastic sheeting.

801.07 Joints for Ductile Iron Pipe. Provide ductile iron pipe and ductile iron fittings with either mechanical joint ends or push-on joint ends unless otherwise shown on the Plans. Provide joints in accordance with AWWA C111.

Provide restrained joints in accordance with those listed in the Division of Water Approved Materials list for 20-inch and larger diameters at all bends, tees and dead ends for thrust restraint, unless otherwise approved by the Engineer or indicated on the Plans. Provide mechanical joint wedge action restraining glands only when approved by the Engineer.

In areas where contaminated soils are present, the Engineer shall be made aware of the conditions immediately and pipe installation shall cease until further instruction. Special "FKM" gaskets may be required to prevent permeation of chemicals into the water main, depending on the type of contamination present. The gasket information shall be submitted to the Division of Water for approval prior to use.

801.08 Joints for Steel and Concrete Pipe. Conform to AWWA C301 for concrete pipe and AWWA C 200 and C206 for steel pipe.

Use a restrained joining system at all bends, tees and dead ends. Provide welded joints for restrained joints in steel pipe. Provide concrete pipe restrained joints in accordance with those approved in the Division of Water Approved Materials List.

Submit design and installation details for approval when providing special joints.

Rubber-Gasketed Joints:

Concrete Pipe: Single weld bell and spigot ring onto steel cylinder. In thrust areas, double weld bell-and-spigot onto steel cylinder.

Steel Pipe:

a. Bells: Formed by either expansion of pipe end over a die, or by segmental expander which stretches steel past its elastic limit, or by attaching sized weld-on bell rings. Attach weld-on bell rings with full-thickness fillet welds, welded inside and out (double-welded). Ensure that the minimum thickness of completed weld-on bell ring equals the thickness of pipe wall in barrel of pipe between joint ends. The City will not allow use of an expanded bell with a Carnegie spigot.

b. Spigots: Size prior to rolling gasket groove. For Carnegie spigots, use only with attached weld-on bells. Attach with full-thickness fillet welds, welded inside and out (double-welded).

Welded Joints: Employ independent certified testing laboratory, approved by Engineer, to perform weld acceptance tests on welded joints. Include cost of such testing in contract unit price bid for Item 801. Furnish copies of all test reports to Engineer for review. Test by magnetic particle test method for lap welds and fillet welds or by X-ray method for butt-welds, for 100 percent of all joint welds. Engineer has final decision to suitability of welds tested.

Weld Acceptance Criteria: Conduct in accordance with ASTM E165 – Standard Test Method for Liquid Penetrant Examination and ASTM E709 – Standard Guide for Magnetic Particle Examination. Use X-ray methods for butt welds, for 100% of joint welds. Examine weld surfaces for the following defects:

a. Cracking

b. Lack of fusion/penetration

c. Slag which exceeds 1/3 (t) where t = material thickness

d. Porosity/relevant rounded indications greater than 3/16 inch; rounded indication defined as one of circular or elliptical shape with length equal to or less than three times its width.

e. Four or more relevant 1/16-inch rounded indications in line separated by 1/16 inch or less edge to edge.

Welder Qualifications: Ensure that all welders engaged to join pipe, fittings, etc. and/or pipe repair have and maintain qualifications under provisions of AWS B2.1, and successfully pass welding testing in accordance with AWWA C206.

Present written welder certification documents to the Engineer for approval prior to any individual performing welding work on any pipeline joints, repairs, fittings or associated work. Provide welder certification appropriate to the work.

Flanged Joints: Provide flanged joints where shown on the Plans in accordance with AWWA C207, standard steel ring Class D, red rubber gaskets, 1/8-inch thick, full-face. Bolts and nuts: ANSI B18.2.1 and ANSI B18.2.2, respectively.

Joint Linings and Coatings:

Internal Joints: Provide non-shrink joint grout for internal joints on steel and prestressed concrete pipe. Prepare grout in small batches to prevent stiffening before use. Discard set grout. Remove defective concrete, laitance, dirt, oil, grease, and other foreign material inside joint with wire brush or hammer. Remove rust and foreign materials from metal surfaces. Allow grouted exterior joints to cure at least 1 hour before compacting backfill. For pipe diameters less than 30-inches, the joint can be "buttered" as described in AWWA C205.

Exterior Joints:

a. Concrete pipe in tunnels: provide zinc coating for joint rings.

b. Joint wrapper and grouting exterior joint space for concrete pipe: Minimum width of 9-inches for 30-inch diameter and smaller; minimum width of 12-inches for diameters greater than 30-inch, hemmed at edge to allow threading with minimum 5/8-inch-wide steel strap. Provide minimum 6-inch-wide polyethylene foam strip sized, positioned, and sewn 1 1/2-inches from the outer edge of the wrapper's two circumferential edges of the polyethylene foam. Pour grout down one side of the pipe until it rises to the other side. Rod or puddle grout to ensure complete filling of joint recess. Agitate for 5 minutes. Add more grout if necessary. Proceed with placement of bedding and backfill when grout mechanically stiffens.

c. Heat Shrink Joint Sleeves for steel pipe: Provide in accordance with AWWA C216. Pipe manufacturer to hold back coating at joints in accordance with shrink sleeve manufacturer's recommendations. Apply manufacturer-approved insulating putty at bell step-offs. For welded joints, apply heat-resistant protective sleeve prior to internal welding. Surface preparation and sleeve application shall be in accordance with manufacturer's instructions. Do not expose joint sleeves to sunlight for more than 90 days. Discard (remove) and replace when exposure exceeds 90 days. Provide a technical representative from the shrink sleeve manufacturer on site at beginning of pipe laying operations to advise Contractor and Engineer regarding installation, repairs, and general construction methods. Include the cost for these items in unit price bid of Item 801.

801.09 Water Mains Appurtenances. Furnish and install, prior to testing, all fittings, blow offs, air releases and water taps in the number of and sizes shown on the plans, or at locations selected by the Engineer. Provide factory-coated carbon steel nuts and bolts, as included in the current Approved Materials List. Coat exposed portions of nuts and bolts with approved bitumastic paint, petrolatum-based tape coating system, or wax tape coating system as identified in the Division of Water Approved Materials List.

Furnish and install all valves as shown or as directed by the Engineer. The City will pay for furnishing and installing valves under other items. Provide valves with mechanical joint or push on ends for 48-inch diameter and smaller ductile iron pipe, unless otherwise shown or approved by the Engineer. For larger than 48-inch diameter ductile iron pipe, provide flanged joints. Provide valves with flanged joint ends for use with concrete and steel pipe. Furnish and lay, under this item, any special casting necessary to make the valve installation as shown on the plans. Furnish and lay all closure pieces, special bends and fittings necessary for the constructing of the pipe line as shown on the Plans.

801.10 Excavation and Pipe Installation. Install all pipe as per the manufacturer's specifications and the City's requirements. Install the pipe according to the proposed horizontal and vertical locations as shown on the plans. Make connections to the existing pipe lines at the locations shown on the plans. If, during the course of the work, unforeseen conditions arise, the Contractor may be directed by the Engineer to change the horizontal or vertical alignment of the pipe line or location of the connection to the existing pipe. For 16-inch diameter and smaller, if the plans do not show the water main grade, install the water main with no less than 4 feet of cover from the proposed final grade. For 20 inch diameter and larger, if the plans do not show the water main grade, provide minimum 6 feet of cover from the proposed final grade.

If a need arises that requires changing the waterline grade, lower the line unless the Engineer gives specific approval to raise the line. When installing the water main in an embankment area, place and compact the embankment as required by 203.05 prior to excavating the water main trench.

Excavate and prepare the trench and lay the pipe in conformance with the applicable parts of the Standard Specifications for Installing Ductile Iron Pipe AWWA C600 (the latest revision thereof) and the City's requirements.

Trench Excavation and Foundation:

Keep pipe trenches free of water. Determine trench excavation widths using following schedule as related to pipe inside diameter (I.D.).

Nominal Pipe Size, Inches	Minimum Trench Width, Inches	Bedding Depth, Inches
16" and less, ≤ 10' cover	I.D. + 24	0
16" and less, ≥ 10' cover	I.D. + 24	6
20" to 30"	I.D. + 24	6
36" and Greater	I.D. + 48	6

For 20-inch diameter and greater, provide Crushed Carbonate Stone (CCS) Size No. 57 as specified in Item 703 – Aggregate for bedding material beneath pipe. Uniformly place and spade full depth to eliminate bridging. Grade trench to provide uniform support along bottom of pipe. Excavate for bell holes after grading the bottom and in advance of placing pipe.

For 16-inch diameter and smaller, the Contractor may use a flat-bottom trench for up to 10 foot depth of cover. For depth of cover exceeding 10 feet, provide 6-inches bedding in accordance with requirements listed above. In areas of rock excavation, provide 6-inches bedding in accordance with requirements listed above. Comply with the requirements of Item 903 for rock excavation.

When cutting into an existing water main, comply with the requirements of the Ohio Administrative Code Chapter 3745-83-02 - Water Distribution System Disruption of Service Rule. Excavate sufficiently below the area of the work to maintain water levels below the water main. If water from the trench enters the existing main, contact the Division of Water immediately. Ensure that sufficiently sized pumps are utilized to remove water from the trench and backup pumps are kept on site for redundancy.

Pipe Laying and Initial Backfill:

Use a fabric type sling, pipe clamp, padded cable, or padded forks when handling pipe and ensure that pipe and polyethylene encasement are not damaged during handling. Do not use chains, unpadded cables or unpadded forks. Use backfill material free of large rocks or stones, or other materials which could damage coatings.

Pipe Haunching (for 20 inch diameter and greater): Provide Crushed Carbonate Stone (CCS) Size No. 57 as specified in Item 703 – Aggregate. Place backfill carefully and simultaneously on each side of pipe to avoid lateral displacement of pipe and damage to joints. Extend the depth of haunching from the trench bottom up to 1/2 times the pipe diameter. If the pipe requires adjustment after placement, remove and re-lay as new pipe. Prevent damage to coating when placing backfill. Place haunching material manually around pipe and spade full depth of lift to prevent bridging and provide uniform bearing and side support.

Initial Backfill: Provide granular material meeting the requirements of 304.02 or 703.11 for 16-inch diameter and smaller, and above pipe haunching for 20-inch diameter and greater. Shovel in-place and compact material using pneumatic tampers in restricted areas, and vibratory-plate compactors or engine-powered jumping jacks in unrestricted areas. Do not exceed 12 inches compacted thickness for a single layer of backfill material. See 801.12 for compaction requirements. Extend initial backfill a minimum of 12 inches above top of pipe.

Thrust Restraints:

Provide concrete backing, supports and/or buttresses on all water mains 16-inch diameter and smaller and at connections to existing pipes, regardless of diameter, as required. Also provide concrete backing at all tees, bends, dead ends and at any other locations shown on the plans or directed by the Engineer. Build these concrete structures to the lines, grades and dimensions shown on the Standard Detail Drawings L-6310, L-6311, L-6312, and L-7001, or as ordered by the Engineer, and construct with Class COC 6 concrete as per Item 499. Include the cost of temporary timber backers and the cost of excavating to line and grade shown for the supports in the unit price bid for Item 801.

On all water mains 20-inch diameter and larger, provide adequate restrained joint lengths. Provide restrained joints at all tees, bends, dead ends and at any other locations shown on the plans. Provide restrained joints with limits designed by an engineer in accordance with manufacturer's suggested recommendations or as shown on the Plans. When installing bends at connections to existing water mains, concrete backing will be required in addition to the restrained joint bend fitting. Provide concrete backing in accordance with the Plans. Prior to ordering the pipe and commencing with construction, submit a pipe laying schedule showing the proposed designed restraining system for the entire water main improvement for approval by the City of Columbus Division of Water.

Include the cost of the restrained joints, backing, supports and/or buttresses or design thereof in the unit price bid for Item 801.

Rubber Gasketed Joints:

During any construction, keep rubber gaskets and lubricants in an area heated to at least 40°F when the outside temperature falls below 40°F. Place gaskets or use lubricant in the bell or on the spigot of the pipe no later than 5 minutes after removal from the heated area. Lubricate all joints according to the manufacturer's recommendations.

Steel Pipe Installation:

Install pipe stulls (cross bracing) prior to placement of pipe, bends, and fittings to prevent deflection during installation. Stulls to remain in place, horizontally and vertically positioned until completion of welding. Remove stulls no sooner than 24 hours after completing placement of backfill to natural ground level or to pavement subgrade level.

Immediately replace damaged plastic end-caps. Do not leave uncapped for more than 4 hours.

Pipe deflection: After backfill completion, test pipe for excessive deflection by measuring actual inside vertical diameter. For maximum allowable deflection, see 801.06. The Engineer may measure deflection along the pipe. The City will not accept arithmetic averages of deflection. If deflection exceeds that specified, perform one of the following:

a. Remove backfill and side support. Reround the pipe and properly replace compacted backfill and side support. Examine cement mortar lining to verify no damage occurred. Replace damaged mortar lining.

b. Remove entire portion of deflected pipe section and install new pipe as directed by Engineer, at no additional cost to the City.

Installation shall comply with manufacturer's instructions and with AWWA Manual M11.

a. Ensure that the pipe manufacturer furnishes the services of a factory trained, qualified, job experienced technician to advise the Contractor and City personnel as necessary in pipe laying and pipe jointing applications. Provide the technician for a minimum of 15 days and 2 trips to the job site. Provide the technician for a minimum of 10 days prior to and during the laying of the first sections of pipe for the technician's first trip. The City will request the remainder of the technical service days in coordination with the Contractor.

b. Ensure that the pipe manufacturer provides the services of the pipe exterior coating manufacturer for a minimum of 5 days divided into 2 trips for tape or polyurethane coatings. Provide a technician capable of advising the Contractor and City personnel as necessary regarding the inspection and repair of the coating. Provide the technician for a minimum of 3 days for the first trip to observe unloading of the pipe from the factory, inspect the pipe exterior coating, and to observe pipe handling and laying by the Contractor. If no exterior coating requires repair during the first trip, obtain coating repair instructions on pipe samples provided by the pipe manufacturer. The Contractor may use the remainder of the technical service days as needed, with approval by the City, during periods when the Contractor makes coating repairs. Obtain documentation from the technical service representative that provides assurance that the Contractor's repairs meet requirements. Submit this documentation to the City prior to the technical service representative leaving the job site.

801.11 Backfill within the Influence of Pavement. This section discusses backfilling above the initial backfill up to ground surface or beneath pavement subgrade within the influence of pavement as defined by Standard Detail Drawing L-6309E.

Unless otherwise shown, specified, or ordered, provide granular backfill material meeting the requirements of 703.11. The City will allow use of Low Strength Mortar Backfill, Type II or III, complying with the requirements of Item 613 as an alternate to compacted granular material. Do not use RPCC for any bedding or backfill material.

Ensure that the moisture content does not exceed less than minus 4 percent of optimum moisture prior to spreading. Shovel in-place and compact material using pneumatic tampers in restricted areas, and vibratory-plate compactors or engine-powered jumping jacks in unrestricted areas. Do not exceed 12 inches for a single layer of compacted thickness. See 801.12 for compaction requirements. Extend the compacted backfill to the top of the pavement subgrade for trenches within traveled areas, and to within 6 inches of the existing ground in all other areas.

Comply with the requirements of 801.12 for the backfill of a water main parallel to the centerline and within proposed or dedicated rights-of-way, but outside the influence line for support of pavement.

Backfill the remaining depth of trench within traveled areas with material specified for pavement replacement. Place and compact base and pavement materials as specified under the applicable repaving item. Strike off the pavement base at the proper depth to accommodate the specified thickness of temporary or permanent pavement.

Backfill the remaining depth of trench outside traveled areas as specified under the seeding or sodding items.

Uniformly wet or dry the backfill as to obtain the specified density. Provide backfill free of sod, debris, frozen earth, foreign objects, metal objects, or large rocks or stones.

801.12 Backfill Outside the Influence of Pavement. Backfill in conformance with the requirements of 801.11 above, outside the influence of pavement, as defined by Standard Detail L-6309E, except as herein modified.

Provide suitable backfill material native to the project, or granular backfill material conforming to the requirements of 703.11. Do not use RPCC for any bedding or backfill material. Dispose of excavated material unsuitable for backfill at no additional cost to the City. Provide granular backfill material from somewhere else. Spread material in successive layers not exceeding a depth of 12 inches. Compact from above the initial backfill to within 6 inches of the existing ground. The following requirements apply to granular material conforming to 304.02, 703.11, and to native material:

Max. Lab. Dry Wt. Lbs./cu. Ft.	Min. Compaction Requirements % Lab. Max.
90-104.9	102%
105-119.9	100%
120 and more	98%

Backfill the remaining 6 inches of excavation with approved material without mounding of fill. Maintain trenches in good and safe condition up to the time of acceptance of the work.

Backfill traveled areas in accordance with 801.11.

801.13 Water Main Cleaning and Flushing. Before applying a hydrostatic test to any newly constructed water main, flush the main or clean and flush as herein prescribed. A designated Division of Water representative shall operate the water supply valve. Use care during the construction operations to ensure the interior surfaces of all pipe and fittings remain in a sanitary condition. Make every effort to keep loose foreign material

out of all pipe and fittings. Temporarily block or cap exposed open ends of pipe during construction. Take particular care to protect the main during temporary work interruptions.

Flush all main sizes 8 inches and smaller through available fire hydrants as directed and witnessed by a designated Division of Water representative. Valving operations may be required to ensure a thorough cleaning of all sections of the main. Ensure flow rates for adequate flushing velocities of 1,000 gallons per minute for 6 inch mains and 1,600 gallons per minute for 8 inch mains or maximum available flows from the system. Clean sections of main not capable of flushing by valving and hydrant operations as directed by the Engineer.

Clean all mains 12 inches and larger by passing a new, properly sized, poly pig through the pipe. Unless permitted by the Division of Water Representative, the City will not allow use of used poly pigs. Use a poly pig with a minimum density of 5 pounds per cubic foot, coated with a double spiral wrap without wire brushes or scrapping tools. Provide acceptable poly pigs in accordance with those listed in the Division of Water Approved Materials list. As an alternative to poly pig, the City will allow actual manned entry inspection of pipes 36" and larger, as approved by Engineer. Remove all debris encountered during the inspection by a method approved by the City.

Prepare the main for the insertion and removal of the poly pig at points identified by the Contractor and approved by the Division of Water representative as insertion ports, if required, and exit ports. Provide all material, equipment and labor to insert the poly pig and construct a sanitary exit port. Where practical, insert the poly pig into the first length of pipe during the initial installation. At the exit port, prevent the backflow of purged water into the main by the temporary installation of mechanical joint bends and pipe joints to provide a riser out of the trench.

Provide pumps and/or ditches to prevent contaminated water from reentering the main. After cleaning the main to the satisfaction of the Division of Water representative, remove all temporary constructions and complete all work necessary to secure the system prior to backfilling insertion and exit sites. The Engineer may require additional poly pig runs when water purged from the main indicates the presence of excessive dirt or debris.

Route all discharged water through an approved erosion control device. Follow stormwater best management practices at all times.

801.14 Hydrostatic Tests. Apply a hydrostatic test to the mains and fire hydrant leads as required in Section 5 of the Standard AWWA Specification C600 for Ductile Iron Pipe, Section 4 of AWWA Specification C604 and M11 for Steel Pipe or AWWA M9 for Concrete Pipe. Test all new water taps to the curb stop. Test each valved section of water main independently of one another unless otherwise approved by the Engineer. Conduct pressure test with all watch valves open and hydrant foot valves closed. Maintain 150 psi of pressure in any tested section for a minimum of two hours. Furnish all materials, make all taps required, and furnish a pump, metering equipment, piping, other equipment and all necessary assistance for conducting the tests.

Fill steel and concrete pipe with water prior to testing and allow to stand in the pipe for at least 24 hours to permit absorption of water into the cement mortar lining. Add water to replace the water absorbed prior to testing.

Before applying the specified test pressure, expel all air from the pipe at air release valves and/or hydrants. Allow the pipeline to stabilize at the test pressure before conducting the hydrostatic test. Do not allow the test pressure to vary by more than 5 psi +/- for the duration of the test. Maintain test pressure within this tolerance by adding makeup water through the pressure test pump into the pipeline. Measure the amount of makeup water by suitable methods. The City will not accept a pipe installation that exceeds leakage specified per Standard Detail Drawing L-6640 (evaluated on a pressure basis of 150 psi).

Locate leaks revealed by this pressure test at no additional cost to the City. Remove and replace cracked or defective pipes, fittings, valves, joints, or other appurtenances, discovered during the pressure test at no additional cost to the City. Repeat the test until satisfactory to the Engineer.

Test against existing valves at the Contractor's risk and in strict compliance with the requirements of the Engineer. If unable to achieve the required test, disconnect from the existing valve, plug and re-test until obtaining satisfactory results. Repair damage caused to existing facilities at no additional cost to the City.

801.15 Chlorination of Completed Pipe Line. After satisfactory hydrostatic testing, the City will chlorinate the completed pipe in accordance with AWWA C651. Any section of water main that is longer than 20 feet in length shall be chlorinated. Hand swabbing methods will only be permitted for sections less than or equal to 20 feet in length. The City will furnish the chlorine, pumping equipment necessary to introduce the chlorine into the chlorination tap, and one man. Furnish and pay for all other labor, material and equipment including chlorination taps and blow-off taps. Only one connection to an existing water main is permitted before disinfection of a new water main has been completed. All other connections must be made after the line has been disinfected. No water service connection permits shall be issued or connections made to any water taps until water mains have been disinfected by the City. Provide taps with tapping valves, sufficient tubing or pipe to extend outside the trench, and an operable valve above ground. Provide blow-offs with sufficient tubing to extend to an approved drainage facility. Do not install tubing or piping directly into a storm sewer. Provide an adequate gap between the end of the tubing or piping and any storm inlet. Provide blow-offs with adequate protection from pedestrian and vehicular traffic. Install blow-offs of sufficient sizes and at appropriate locations, as per AWWA C651, or as directed by the Engineer. Chlorination taps and blow-offs shall be installed within 2 feet of the end of the tested section, or as directed by the Engineer. When possible, use caps/ plugs, with taps of the sufficient size installed directly on the cap/plug, at the ends of each tested section. Do not reuse corporation stops, 2-inch and under, used in the chlorination process as part of a water tap, air release, or any other permanent feature of the water main. The time and the section of line to be chlorinated shall be approved by the Division of Water. The Division of Water will notify the Contractor when to remove the temporary blow-offs and corporation stops. Plug the blow off hole with an approved plug as identified in the Division of Water Approved Materials List.

Hand swab all pipes and fittings with unscented household bleach, in accordance with the sections of AWWA C651, that are not otherwise disinfected.

801.16 Main Shuts. Prior to the start of proposed water main improvement, submit a plan and an accompanying schedule identifying the location and estimated dates for water main shuts to the Division of Water for approval.

Only Division of Water personnel will operate valves. Operation of existing valves by the Contractor or their representative may result in penalties as identified in Chapter 1113 of the City Code.

For shuts on large diameter mains (20" or larger), notify Division of Water personnel at least five working days in advance of the actual water main shut. For all other shuts, notify Division of Water personnel at least three working days in advance of the actual water main shut. Notify and coordinate water main shuts with all affected customers. City personnel will work with the Contractor in identifying affected customers and will provide a sample notification letter. The City will approve the final notification letter. The Division of Water personnel may re-schedule the main shut at its discretion if the Contractor appears unprepared to perform the work scheduled during the shut. Some examples of being unprepared for shuts include having insufficient pumps for dewatering, failing to excavate sufficiently below the main, having incorrect materials or equipment on-site, and failing to provide advanced notification to customers. The City will not pay for costs associated with lost time due to lack of preparation by the Contractor. All affected customers shall be notified of non-shuts due to rescheduling or delays in the work at no additional cost to the City.

To minimize impacts to customers, the City may require the Contractor to make shuts at night and/or on weekends. Include costs incurred to perform contract work after regularly scheduled hours due to main shuts and all cost associated with coordinating shuts with the City in Item 801.

No shuts are permitted to occur on or one (1) business day before a National Holiday or National Holiday weekend, unless otherwise approved by the Engineer.

801.17 Certification. Furnish a sworn statement from the Contractor certifying that the material manufacturer performed all the required tests and that the pipe and fittings comply with the requirements specified.

801.18 Method of Measurement. The City will pay for furnishing and laying pipe based on plan view dimensions (footages along the centerline of the horizontal alignment).

The City will adjust compensation for ductile iron fitting changes ordered by the Engineer to reflect an increase or decrease in payment equal to the weight difference between the fitting shown on the Plans and the fitting actually installed for ductile iron pipe. The City will include the weight of glands required to install fittings in the fitting weight.

The City will compute number of cubic yards of concrete backing, supports or buttresses from dimensions shown on the standard drawings therefore or as measured in the field if the Engineer ordered special backing. The City will make no allowance for backing poured larger than the dimensions shown on the standard drawings unless the Engineer gave advance approval.

The City will adjust compensation for any backing changes ordered by the Engineer to reflect an increase or decrease in payment equal to the cubic yard difference between the volume of backing shown on the standard drawings and that ordered by the Engineer.

For water mains 20" in diameter and greater, the City will pay for corrosion protection on a lump sum basis. Lump sum payment includes labor, materials and equipment necessary to install required corrosion protection devices as required in 801.02. The City will make no separate payment for corrosion protection on 16" diameter and smaller water mains.

All items requiring removal for excavation of the trench as shown on the plans shall be included in Item 801, unless otherwise specified. Include the cost of saw cutting in the items of the Contract and the City will not pay for saw cutting separately.

The City will base payment for concrete or steel pipe, when directed by the Engineer to install extra fittings as required to avoid unforeseen obstacles, based on the following:

a. The City will pay for each extra fitting requested by the Engineer and delivered to jobsite according to unit price for "Extra Fittings, Concrete or Steel, Complete in Place."

b. The City payment will include full compensation for items necessary for installation and operation of water main.

801.19 Basis of Payment. The City will pay for all work done under these items at the unit price specified. The City payment will include full compensation for all labor, material and equipment required to furnish and lay the pipe and appurtenances as herein specified.

The City will make payment at the contract price for:

Item	Unit	Description
801	Linear Foot	____ Inch Water Pipe and Fittings
801	Lump Sum	Corrosion Protection (20" diameter and greater)
801	Cubic Yard	Concrete Backing Class COC 6, Increase or Decrease
801	Pound	Ductile Iron Fittings, Increase or Decrease
801	Each	Extra Fittings, PCCP Concrete or Steel, Complete in Place
801	Lump Sum	Cathodic Protection System Design and Installation – Steel Pipe

ITEM 802 VALVES AND APPURTENANCES

802.01 Description

802.02 Gate Valves
802.03 Butterfly Valves
802.04 Not Used
802.05 Valves 2 Inch and Smaller
802.06 Extension Stems
802.07 Not Used
802.08 Valve Boxes
802.09 Valve Supports
802.10 Operation
802.11 Basis of Payment

802.01 Description. Provide all work necessary for furnishing and installing valves of the type, sizes and locations shown on the plans and as herein specified. Install all valves with the factory-coated carbon steel bolts coated with an approved bitumastic paint and wrap with an approved polyethylene wrap or wrap with an approved wax-tape, or petrolatum-based tape coating system as included in the current Approved Materials List.

802.02 Gate Valves. Provide gate valves conforming to AWWA C509 or AWWA C515 except as modified herein. Provide Division of Water approved double disc, parallel seats or resilient seated; non-rising stem, left hand open (counter-clockwise), valves with rubber "O" rings, packing seals and mechanical joint ends unless otherwise specified or approved by the Engineer. Provide butterfly valves for valves 20 inch and larger, with the exception of tapping valves.

Provide vertical design, without by-pass, gate valves for valves 16 inch and smaller.

Provide horizontal design, with by-pass, gate valves for valves 20 inch and larger used for tapping valves. Provide horizontal, totally enclosed valves with enclosed extended gear cases designed for buried service.

Ensure that mechanical joint ends shall conform to the requirements of Item 801. Provide flanged joint ends, where specified, that conform to requirements of AWWA C509 or C515 with factory-coated carbon steel bolts and nuts as included in the current Approved Materials List and full face rubber sheet gaskets. When specified, furnish and install hub and bell and spigot joints with all necessary jointing material.

802.03 Butterfly Valves. Provide butterfly valves that conform to the AWWA Standard Specification for Rubber-Seated Butterfly Valves; Designation AWWA C504 except as herein specifically modified. The Administrator, Division of Water must approve Bonded Seat Butterfly Valves for use from the current Approved Materials List.

1. **Design.** AWWA Class 150B valves designed for 150 non-shock shut-off pressure and a velocity of 16 feet per second. Provide valves and appurtenances, including operators, suitable for buried and submerged service.

Provide valves for use with ductile iron pipe with mechanical joint ends or push-on ends. Provide ends with factory-coated carbon steel tee head bolts, factory-coated carbon steel hex nuts, retainer glands, and rubber gaskets.

Provide valves with flanged joint ends for use with prestressed concrete and steel pipe.

2. **Bodies.** Either cast iron conforming to ASTM A126, Class B or ASTM A48, Class 40 or ductile iron conforming to ASTM A536, Grade 65-45-12.

3. **Shafts.** Unless otherwise approved, stainless steel, or monel, in accordance with AWWA C504, Class 150B. Provide a disc to shaft connection of Type 304 stainless steel or Monel squeeze pin or taper pin held by means of a nut. Indicate the disc position on the valve shaft with a scribed line or other approved method.

4. **Discs.** Provide valves designed to seat at 90 degrees to the pipe axis with a disc of the flow-through design for 30 inches and larger. Provide all discs with a Type 304 stainless steel edge.

5. **Seats.** Designed for and installed in the valve body. Provide 20 inch valves with seats bonded to the valve body in accordance with AWWA C504. Provide valves 24 inches and larger with seats retained in a dove tail groove by an epoxy cast retaining ring or mechanical fasteners or other approved method. Aircraft wire all internal seat retainers when using mechanical fasteners.

6. **Operators.** Suitable for buried and submerged service and installed by the valve manufacturer, and tested in accordance with AWWA C504. Provide operators designed to deliver an output torque sufficient to operate the valve under the design conditions.

Provide operators designed to produce the specified output torque with a maximum input torque of 150 foot-pounds applied to the operating nut. Provide worm gear or traveling nut type operators or as approved by the Administrator, Division of Water. Provide operators designed to accept 450 foot-pounds of input torque without damage to the operator.

Provide operators that require no less than 30 turns, applied to the wrench nut, to completely open (close) the valve from completely closed (open) position.

Provide only left-hand (counter clockwise) opening operators.. When installing butterfly valves, set the operator on either the south or east side of the proposed water main.

802.04 Not Used.

802.05 Valves 2 Inch and Smaller. Curb stop type conforming to requirements of 805.04 or a 2 inch gate valve.

802.06 Extension Stems. Provide an extension to bring the top of the operating nut to within 24 inches of finished grade elevation when the top of the operating nut measures more than 7 feet below finished grade. Include the extension stem costs under Item 802.

802.07 Not Used.

802.08 Valve Boxes. Unless otherwise noted on the plans or directed by the Engineer provide Columbus Standard Heavy Duty Three Piece Valve Boxes for all valves 16 inch and larger, and valves within traveled areas. Provide Columbus Standard Regular Duty Three Piece Valve Boxes for all other valves 3 inch up to but not including 16 inch. Provide valve boxes approved for use in the current Approved Materials List. Mark covers for the regular duty boxes "WATER."

Provide a curb box per Standard Detail Drawing L-1001 where installing 2 inch and smaller curb stops in grass areas, asphalt traveled areas, or concrete traveled areas. For curb stops installed within gravel areas only, cover the top section of the valve box with a Columbus Standard Ferrule box and cover per Standard Detail Drawing L-6320.

Install all valve boxes centered vertically over the valve operating nut so that the box provides maximum cover of the operating housing. Install valve boxes plumb and ensure that valve keys operate unimpeded. Include the cost of the valve boxes in the unit price bid for the various valve types and sizes.

Refer to the requirements of 604.03 regarding allowable tolerances for valve lids.

802.09 Valve Supports. Provide concrete supports of the size shown on the Standard Detail Drawing L-6306 under all valves. Provide valve restraints if necessary. Use valve restraint materials in accordance with the current Approved Materials List. Include the cost of valve restraints in the unit price bid for the various valve types and sizes.

802.10 Operation. The Division of Water personnel only will operate valves that affect the flow of water through water mains in service, or any valves installed against a City of Columbus main. The City will not guarantee water tight valve shuts. Coordinate all valve shuts with Division of Water personnel. The Division of Water will require a minimum of 72 hour notice prior to a valve shut.

802.11 Basis of Payment. The City will pay for all work performed under this item at the unit price as bid and will consider the unit price as full compensation for furnishing and installing the various types and sizes of valves specified including concrete valve supports, restraints, and valve boxes.

The City will make payment at the contract price for:

Item	Unit	Description
802	Each	____ Inch Valve and Appurtenances
802	Each	____ Inch Butterfly Valve and Appurtenances

ITEM 803 TAPPING SLEEVES AND VALVES

803.01 Description
803.02 Valves and Sleeves for Mains
803.03 Installation
803.04 Valve Boxes
803.05 Concrete Supports
803.06 Not Used
803.07 Basis of Payment

803.01 Description. The Contractor shall provide all work required to furnish and install the tapping sleeves and valves complete in service and as herein specified.

803.02 Valves and Sleeves for Mains. Unless otherwise approved by the Administrator, Division of Water, provide flanged joint type tapping sleeves designed for use on the class of pipe the Contractor plans to tap. Provide tapping sleeves in accordance with the current Approved Materials List.

Provide tapping valves that conform in all respects to the requirements of Item 802. Provide inlet joints designed for the sleeve provided. Provide flanged joint outlet ends and seat rings of sufficient size to permit passage of the tapping machine cutters.

803.03 Installation. Expose the existing main to verify dimensions prior to ordering sleeve and valve. If the existing pipe is covered with polyethylene wrap, the pipe shall be wrapped with tape all the way around the pipe at a point 24-inches from each end of the tee or tapping sleeve, prior to removing the wrap. If the connection requires more than 24-inches of pipe on either side of the tee or tapping sleeve, then the tape shall be wrapped at a point 12-inches past the connection point. The polyethylene wrap shall then be removed between the taped sections to expose the existing pipe for the connection. After installation of the sleeves and valves at the designated locations, but before cutting, ensure installation of any concrete supports or backers and pressure test the sleeves and valves to check for leaks with the valve in the closed position. Test the sleeves and valves for taps into ductile iron mains, under 150 pounds per square inch air or water pressure. For taps into concrete mains an outlet size less than 12 inches, test the sleeves and valves under 75 pounds per square inch. For taps into concrete mains, where the outlet size 12 inches or greater, test the sleeves and valves 110 percent of the line pressure. Pressure test for a minimum fifteen (15) minutes. When the valves and sleeves show no leaks, make the cut through the wall of the pipe under pressure. Adequately support valves prior to cutting. After installation, the entire connection area, whether previously covered with polyethylene or not, shall be wrapped with polyethylene to a point 12-inches past the connection

points on the existing main. Special care shall be taken when installing wrap over any sharp edges and left somewhat loose to minimize the potential for punctures during backfill operations. Excavate and backfill as specified under Item 801.

803.04 Valve Boxes. Provide tapping valves with the "Columbus Standard Heavy Duty Valve Boxes" as provided under Item 802 unless otherwise specified.

803.05 Concrete Supports. Provide concrete backers and supports per Standard Detail Drawings L-6306 and L-6312 or as designated by the Engineer. Include concrete for thrust backer and valve support costs and the cost of excavating to line and grade shown for the supports in the unit prices bid under this item.

803.06 Not Used.

803.07 Basis of Payment. The City will pay for all work under this item at the unit price bid and will consider the unit price as full compensation for all work required to make a complete installation including the furnishing and installing of concrete supports and backing, restraints, and valve boxes as specified.

The City will make payment at the contract price for:

Item	Unit	Description
803	Each	___ Inch x ____ Inch Tapping Sleeve and Valve and Appurtenances.

ITEM 805 WATER TAPS AND WATER SERVICE LINE TRANSFERS

805.01 Description
805.02 Water Main Connection
805.03 Pipe and Fittings
805.04 Control Valves and Boxes
805.05 Installation
805.06 Method of Measurement
805.07 Basis of Payment

805.01 Description. Provide all work necessary to furnish and install water taps and transfer water service lines, where shown on the plans or otherwise required and in accordance with these specifications. The City defines water "tap" and "service line" as stated in Columbus City Code 1105.01.

Provide new water taps consisting of all pipe, valves, fittings and appurtenances required from and including the water main connection to and including the control valve and box. Wrap new water taps with an approved polyethylene wrap or dielectric tape material for a minimum clear distance of 3 feet away from the water main, in accordance with Standard Detail Drawing L-1004. Prior to constructing any new water tap, obtain a water service connection permit from the Division of Water.

When performing a water service line transfer, provide a water tap consisting of all pipe, valves, fittings and appurtenances required from and including the water main connection to and including the control valve and connection to the service line and the abandonment of the existing water tap. Relocate the existing curb box to the new curb stop location. If the Contractor discovers a box damaged due to no negligence of the Contractor, provide and install a new curb box. If required, the City will pay for a ferrule box, in addition to the new curb box, under the appropriate bid items. Replace boxes damaged by the Contractor at no additional expense to the City. Verify the location of the existing curb box and size of water tap prior to installing the corporation stop on the new or existing main.

Complete surface restoration in accordance with the requirements of the appropriate bid items. The City will pay for this work also in accordance with the requirements of the appropriate bid items.

805.02 Water Main Connection. For water taps 2 inch and smaller, make the water main connection using a corporation stop listed on the current Approved Materials List. Install all corporation stops at the 10 or 2 o'clock position. Locate corporation stops no closer than 24 inches to any other corporation stop, valve, bend, tee, or joint.

When making a tap on pipe encased with polyethylene, wrap a minimum of three layers of tape completely around the pipe to cover the area where tapping machine will contact the pipe. Install the corporation stop directly through the tape and polyethylene. Repair any damage after the installation with tape or an additional wrap of polyethylene film. If a saddle is used, wrap the saddle with polyethylene after installation. Regardless of whether the pipe is covered with polyethylene, wrap the copper water tap at least three feet back from the installation with tape or additional polyethylene film to prevent electrolysis. Refer to Standard Detail Drawing L-1004.For water taps 3 inch and larger, use a tee and gate valve for the water main connection if installed with the water main or a tapping sleeve and valve if installing the tap on an existing water main or as indicated on the plans. Secure valves to the water main by anchoring tees, anchoring pipe of minimum length, or by other means approved by the Engineer. Use anchoring tees and other restrained fittings as listed on the current Approved Materials List. If the existing pipe is covered with polyethylene wrap, the pipe shall be wrapped with tape all the way around the pipe at a point 24-inches from each end of the tee or tapping sleeve, prior to removing the wrap. If the connection requires more than 24-inches of pipe on either side of the tee or tapping sleeve, then the tape shall be wrapped at a point 12-inches past the connection point. The polyethylene wrap shall then be removed between the taped sections to expose the existing pipe for the connection.

After installation, the entire connection area, whether previously covered with polyethylene or not, shall be wrapped with polyethylene to a point 12-inches past the connection points on the existing main. Special care shall be taken when installing wrap over any sharp edges and left somewhat loose to minimize the potential of puncture during backfill operations.

Provide service clamps or tapping saddles for all water taps made under pressure into 3 inch water mains and for other main and tap sizes as follows:

Size and Type of Water Main	Maximum Water Tap Size Permitted Without Use of Saddle
4 Inches Cast or Ductile Iron	3/4 Inch
6 Inches Cast or Ductile Iron	1 Inch
8 Inches Cast or Ductile Iron	1 1/2 Inches

Provide compression tees for taps on 2 inch and smaller water mains.

Provide service saddles for 3 inch and larger water mains of double strap design, and as listed on the current Approved Materials List.

805.03 Pipe and Fittings. For water taps 2 inch and smaller, use Type K, soft temper copper tubing conforming in all respects to ASTM B 88 or Federal Specification WW-T-799 for all pipe from the water main connection to the control valve, unless specifically called for differently on the plans.. Use fittings of high quality copper brass with approved compression type joints. Do not use fittings between the water main connection and the control valve, unless otherwise approved by the Division of Water.

Use ductile iron pipe for water taps 3 inch and larger up to the meter inlet and valve on the meter by-pass line. Provide ductile iron pipe and fittings that conform to requirements of Item 801.

805.04 Control Valves and Boxes. Use curb stops without drain in accordance with the current Approved Materials List for control valves for 2 inch and smaller water taps. Provide boxes in accordance with the current Approved Materials List. Provide box lids with the word "WATER" cast neatly and legibly on it and held securely in place by a bronze or brass bolt. Provide a box with an enlarged base section, in accordance with the current Approved Materials List when using a 2 inch curb stop. Include a Columbus standard ferrule box and cover in the top section of the curb box where installing 2 inch and smaller curb stops within gravel areas. Install a concrete paver block, minimum size 4-inches wide by 8-inches long by 2-inches thick, under all curb stops.

Provide control valves for 3 inch and larger water taps that conform to requirements of Item 802. Provide valve boxes that conform to Item 802. All water taps 3 inch and larger which are totally or partially under existing or future pavement shall have a control valve and box provided in addition to the valve and box installed with the water main connection. The control valve shall be installed at the location shown on the plans or approved by the Engineer.

For 3 inch and larger water taps not under pavement or traveled portion of right-of-way, a second valve will not be required unless shown on the Plans. Use the valve installed at the water main connection as the control valve and provide with a valve box in conformance to Item 802.

805.05 Installation. Install 3 inch and larger water taps in accordance with Items 801, 802 and 803. Install water taps 2 inch and smaller by jacking or open cut methods, unless the plans specify one method or the other. Do not bend or kink the pipe nor strain the pipe joints when jacking the pipe. Install the pipe from the water main connection to the control valve to the grade and elevations shown on the plans, but in no case provide less than 3 feet 6 inches of cover. Minimize bends in taps and obtain bending approval, if necessary to bend, from the Engineer prior to installation. Wrap new water taps with an approved polyethylene wrap or dielectric tape material for a minimum clear distance of 3 feet away from the water main, in accordance with Standard Detail Drawing L-1004. Locate curb boxes l foot from the edge of the proposed or existing sidewalk between the sidewalk and the curb, 2 feet inside the right-of-way or easement line in areas with no existing or proposed sidewalk, or as indicated on the construction plans. Align curb stops so that the control valve is perpendicular to the structure on the property, unless otherwise indicated on the plans. All control valves, regardless of size, shall be installed at a depth of cover between 42-inches and 60-inches.

Pressure test all water taps from the water main connection to the control valve, including the valve at the main (if applicable). Pressure test all service lines from the control valve to the meter inlet. No allowable leakage permitted on taps or service lines. Any leakage shall be repaired. Test water taps and service lines 2 inch and smaller at normal city water pressure, unless installed with the construction of a water main, in which case test per Item 801. Test water taps and service lines 3 inch and larger at 150 psi in accordance with requirements of Item 801 up to the meter inlet and valve on the meter by-pass line.

For all water service transfers, after completing testing, connect the water tap to the existing service line and abandon the existing water tap. Attempt to coordinate with the customer prior to performing water service line transfers. Unless otherwise approved by the Engineer, water service line transfers are not permitted on Fridays (or Thursdays if the Contractor is only working Monday through Thursday) unless the Contractor is able to verify the customer has water through verbal confirmation. On Fridays (or Thursdays if the Contractor is only working Monday through Thursday), confirming water service line transfer by means of a hose bib only is not permitted.

Backfill all excavations in accordance with the requirements of Item 801.

805.06 Method of Measurement. The City will use the entire water tap and/or water service line transfer as defined herein as the basis of payment.

805.07 Basis of Payment. The City will pay the unit price shown in the proposal and will consider the payment as complete compensation for providing all work necessary to furnish and install the water tap and/or water service line transfer or any component part thereof.

The City will make payment at the contract price for:

Item	Unit	Description
805	Each	_____ Inch Curb Stop
805	Each	Curb Box
805	Each	C.I. Ferrule Valve Box and Cover
805	Each	_____ Inch Water Tap
805	Each	_____ Inch Water Service Line Transfer
805	Each	_____ Inch Curb Stop, Relocated

ITEM 806 CASING PIPE

806.01 Description
806.02 Requirements
806.03 Reinforced Concrete Casing Pipe
806.04 Steel Casing Pipe
806.05 Corrosion Protection of Steel Casing Pipe
806.06 Shop Drawings
806.07 Placing of Casing Pipe
806.08 Casing Spacers
806.09 Casing Pipe End Seals
806.10 Basis of Payment

806.01 Description. The Contractor shall furnish and install casing pipe and corrosion protection where shown on the plans and as herein specified.

806.02 Requirements. Furnish and install casing pipe in conformance with the requirements and regulations of the appropriate agency, utility and the City of Columbus. Prepare necessary shop drawings, working schedule, description of type of materials and methods of construction in conformance with Standard Detail Drawing L-6324. For ductile iron carrier pipe, wrap the carrier pipe with polyethylene tubing in accordance with 801.03.

Before commencing work on the casing pipe, present evidence to the satisfaction of the Engineer to prove previous experience in tunneling similar to that found on the project, or employ a superintendent able to furnish such evidence. Keep the superintendent continuously on site while performing the work until the tunnel work is completed. Provide qualifications for all personnel installing the casing pipe.

Notify the appropriate agency or utility at least two working days in advance of commencing any construction work on the casing pipe.

Include all costs (i.e. the furnishing of watchmen, inspectors and supervision by their forces) which may result from agency or utility requirements, unless otherwise indicated in the Contract Documents.

Provide casing pipe of a diameter in accordance with Standard Detail Drawing L-6324.

806.03 Reinforced Concrete Casing Pipe. Provide culvert pipe meeting the requirements of ASTMC-76 of the class shown on the plan for reinforced concrete casing pipe.

806.04 Steel Casing Pipe. Provide steel casing pipe meeting ASTM Specifications 35,000 PSI yield strength and 60,000 PSI tensile strength, or approved equal, to serve as a casing for the water main. Install casing pipe within the limits and at the location shown on the plans. Coat the casing pipe per the manufacturer's recommendations for Coal Tar Epoxy coating as included in the current Approved Materials List. Repair damage to the coating per the manufacturer's recommendations. Provide steel casing pipe with a minimum wall thickness of 0.375 inches unless otherwise approved by the Engineer.

806.05 Corrosion Protection of Steel Casing Pipe. The City may require corrosion protection on critical crossings (i.e. Railroads, State highways, etc.) as shown on the Plans.

806.06 Shop Drawings. Prepare the shop drawings referred to above and send to the Engineer for review, checking and approval. If the shop drawings, methods of construction and work schedule meet with the approval of the Engineer, the Engineer will forward to the appropriate agency or utility for its approval.

806.07 Placing of Casing Pipe. Place the casing pipe using industry standards for driving or tunneling methods. Properly size and locate boring pits based on existing field conditions, including all utilities. Repair any damages that result from the installation of the casing pipe at no additional cost to the City of Columbus. Prior to installing the casing pipe, submit a plan of means and methods for the installation of the casing pipe.

806.08 Casing Spacers. Install casing spacers on the carrier pipe. Position the spacers on the carrier pipe in the center of the casing pipe and provide restraint against movement. The City will not allow use of wooden skids with steel bands for casing spacers.

Construct casing spacers of a two piece shell. Construct the shells and risers of 14 Gauge steel hot rolled and pickled carbon steel and construct the risers of 10 Gauge steel. Provide the carbon steel shells and risers with a thermoplastic polymer coating. Provide runners with beveled edges and constructed of glass reinforced polymer. Provide liners with a minimum thickness of 0.90" and constructed of EPDM or flexible PVC. Provide 5/16" zinc electroplated steel bolts, nuts and washers for fasteners. Position and dimension casing spacers in accordance with Standard Detail Drawing L-6324. Provide casing spacers as listed in the current Approved Materials List.

806.09 Casing Pipe End Seals. Seal the ends of the casing pipe with casing pipe end seals consisting of flexible molded synthetic rubber with ends sized appropriately to fit the casing and carrier pipes. Use end seals that provide a watertight seal between the carrier pipe and the casing pipe opening. Use stainless steel hose clamps for fastening hardware. Coat end seal fastening hardware with an approved bitumastic paint or wrap with an approved wax-tape, or petrolatum-based tape coating system as included in the current Approved Materials List. Provide end seals as listed in the current Approved Materials List.

806.10 Basis of Payment. The City will pay the unit price bid per linear foot and will consider payment to include the furnishing and placing of the casing pipe, together with all excavating, casing spacers, end seals, corrosion protection system, all types of pumping, concrete supports, pits and openings, removal and disposal of water in accordance with 901.16, furnishing of all signalers and inspectors, together with all labor, tools, material, equipment and appurtenances required to complete the encasement in good and acceptable condition. The City will make this payment in addition to the price bid for the laying of the water main (carrier pipe) in ordinary excavation.

The City will make payment at the contract price for:

Item	Unit	Description
806	Linear Foot	____ Inch Casing Pipe

ITEM 807 ADJUST VALVE BOXES AND CURB BOXES TO GRADE

807.01 Description
807.02 Material
807.03 Basis of Payment

807.01 Description. The Contractor shall furnish all labor, material and equipment required to raise or lower existing valve boxes and/or curb boxes to the grade and location shown on the plans.

807.02 Material. Excavate around the valve box or curb box, as required, to permit the raising or lowering of the valve box or curb box. Adjust any screw type boxes without the use of additional material providing ample thread remains on the box to provide adequate rigidity to the box. Provide sections of box stem to adjust the top to the required grade for non-screw type boxes and screw type boxes without ample thread. Secure new sections of box stem adequately to the existing stems. Install new components when ordered by the Engineer to replace the broken, existing casting.

Adjust existing valve boxes to grade using a riser as specified in Standard Detail Drawing L-6316B.

After adjusting the box to the proper grade, backfill the hole as specified under Item 801.

Replace pavement or sidewalk, damaged in connection with the work under this item, equal to the existing. Include the cost in the price bid for adjusting valve boxes or curb boxes to grade.

Provide existing valves located within existing or proposed pavement, driveways, or other traveled areas with a Columbus Standard heavy duty valve box. Use boxes that are included on the Approved Materials List.

807.03 Basis of Payment. The City will consider the price bid for adjusting the various valve boxes or curb boxes to grade as full compensation for all labor, material and equipment to complete the work as covered in these specifications including backfill and sidewalk or pavement replacement.

The City will consider the unit prices bid for Columbus Standard heavy duty valve box as full compensation for the heavy duty valve box complete and installed to final grade.

The City will make payment at the contract price for:

Item	Unit	Description
807	Each	Valve Boxes Adjusted to Grade
807	Each	Valve Boxes Adjusted to Grade using Riser
807	Each	Curb Boxes Adjusted to Grade
807	Each	Columbus Standard Heavy Duty Valve Box

ITEM 808 RELOCATING, ABANDONING, CUTTING AND PLUGGING (OR CAPPING) WATER MAINS AND WATER TAPS

808.01 Description
808.02 Relocation of Water Mains
808.03 Lowering of Water Mains
808.04 Relocation of Water Taps (2 inch and smaller)
808.05 Abandonment of Water Mains and Water Taps (3 inch and larger)
808.06 Abandonment of Water Mains and Water Taps (2 inch and smaller)
808.07 Cutting and Plugging (Capping)
808.08 Method of Measurement
808.09 Basis of Payment

808.01 Description. Under this item, the Contractor shall provide all labor and material necessary to abandon, relocate, lower, and/or cut and plug (cap) existing water mains and/or water taps as shown on the plans or specified herein. The Contractor shall notify all water consumers affected by a water shutdown of the approximate length of the shutdown at least 24 hours in advance.

On water mains the Contractor cuts and plugs or relocates, remove all visible valve boxes no longer in service. The City will pay for the required surface restoration for under the appropriate bid item(s).

808.02 Relocation of Water Mains. Complete installation of relocated water mains in accordance with Item 801 and as required on the plans, unless otherwise specified by the Engineer. Lay, test, and chlorinate (by City) the relocated line prior to connection of said line(s) to the existing water main(s). Hand swab all pipes and fittings not otherwise disinfected. The Division of Water will determine the amount of chlorine used during hand swabbing operations.

808.03 Lowering of Water Mains. Complete installation of lowered water mains in accordance with Item 801 and as required on the plans, unless otherwise specified by the Engineer. Lay, test, and disinfect (using hand swabbing method) the lowered line prior to connection of said line(s) to the existing water main(s). Water main lowerings shall be performed as per Standard Detail Drawing L-7401, Typical Water Main Lowering, unless otherwise specified in the contract plans or by the Engineer.

808.04 Relocation of Water Taps (2 inch and smaller). This work consists of installing a new curb stop, relocating the existing curb box and, where necessary, furnishing and installing new pipe and/or curb boxes, in accordance with Item 805 and Standard Detail Drawings L-7102A and L-7102C. Uncover the existing service line from the existing curb stop to the proposed curb stop location. After giving the water customer at least 30 minutes advance notice, close the existing curb stop. Install a new curb stop at the new location. Prior to completing the connection of the new curb stop to the existing water service line, open both curb stops and flush out any foreign matter. Keep the old curb stop open and reopen the new curb stop after completing installation to test for leaks under normal City water pressure. Repair all leaks before backfilling.

Where required, furnish and install new pipe from the existing curb stop to the new curb stop. Replace all existing galvanized steel, poly tubing, or lead pipe all the way back to the water main.

Relocate the existing curb box to the new curb stop location. Provide and place a new curb box for boxes damaged due to no negligence of the Contractor. The City will pay for the new boxes under Item 805. Replace boxes damaged by the Contractor at no additional expense to the City.

808.05 Abandonment of Water Mains and Water Taps (3 inch and larger). Abandon existing water mains and/or water taps, 3 inch and larger, at the main by removing the existing tee and installing sleeves, unless otherwise indicated on the plans or as directed by the Division of Water Engineer. Perform water main abandonment after transferring all affected water service lines and no sooner than 24 hours after shut down of the line designated for abandonment.

Remove all visible valve boxes, fire hydrants, and curb boxes on the abandoned water main no longer in service. The City will pay for the required surface restoration under the appropriate bid item(s).

808.06 Abandonment of Water Mains and Water Taps (2 inch and smaller). Where shown on the plans or directed by the Engineer, abandon existing water mains and/or water taps, 2 inch and smaller, at the corporation stop. Perform water main abandonment after transferring all affected water service lines and no sooner than 24 hours after shut down of the line designated for abandonment. Where making abandonments at existing corporation stops, shut the corporation stop and insert a copper disc into the flare nut on the outlet side of the stop. Use a disc in accordance with the current Approved Materials List. Submit alternate methods of abandonment to the Engineer for approval when a copper disc does not secure a tight shut or the Contractor needs to make the shut at a point other than an existing corporation stop. The City will make no additional payment for this work.

Remove all visible valve boxes and curb boxes on the abandoned water main no longer in service. The City will pay for the required surface restoration under the appropriate bid item(s).

808.07 Cutting and Plugging (Capping). Transfer all affected water service lines and shut the existing water main down for 24 hours before cutting and plugging the line. Cut the existing pipe at the point designated on the plans or by the Engineer. Use a cutting method approved by the Engineer. Use either mechanical joint or slip joint plugs and/or caps, as required in connection with the work under this item, manufactured in accordance with AWWA Specification C-110. After installing the plug or cap, install a backing or restraint system to adequately brace the plug or cap. All exposed pipe and appurtenances shall be wrapped with polyethylene encasement in accordance with Standard Detail Drawing L-1003. The City will allow temporary backing against the abandoned pipe. Install the permanent backing in accordance with 801.10. After plugging or capping the water main and installing permanent backing, backfill the hole as specified under Item 801.

808.08 Method of Measurement. The City will measure relocated water mains for payment on the basis of linear feet actually relocated according to size. The City will measure lowered water mains for payment on the basis of each water main lowered according to size.

The City will measure relocated water taps for payment on the basis of each water tap actually relocated according to size. The City will make no separate payment for new water tap piping, as this cost shall be included in the unit price bid for the water tap actually relocated.

The City will measure abandoned water taps for payment on the basis of each tap actually abandoned according to size. The City will measure water mains abandoned for payment on the basis of each water main of each size actually abandoned.

808.09 Basis of Payment. The City will consider the unit price bid for abandoning water mains and water taps as full compensation for all labor, material and equipment required to complete the work as required in the above specifications and shown on the plans. The City will pay for pavement or sidewalk replacement under the appropriate items.

The City will consider the unit price bid for cutting and plugging (capping) water mains and water taps as full compensation for all labor, material and equipment required to complete the work as required in the above specifications and shown on the plans. The City will pay for pavement or sidewalk replacement under the appropriate items.

The City will consider the per each unit prices bid for water tap relocations as full compensation for all labor, material and equipment required to complete the relocation, including the cut and plug of the existing water main, the installation of the replacement pipe, the addition of valves as requested, and the transfer of all water main appurtenances. The City will pay for pavement and/or sidewalk replacement for under the appropriate items.

The City will consider the linear foot prices bid for water main and/or water tap relocations, as full compensation for all labor, material and equipment required to complete the relocation. The City will pay for the transfer of water main appurtenances, the addition of valves, as required, and the sidewalk and/or pavement replacement for under the appropriate items. The City will base payment for replacement pipe, measured as described under Item 801 at the unit price bid.

The City will consider the per each unit prices bid for water main lowerings as full compensation for all labor, material and equipment required to complete the lowering, including the removal of the existing water main, the installation of the replacement pipe, the addition of valves, as required, and the transfer of all water main appurtenances. The City will pay for pavement and/or sidewalk replacement for under the appropriate items.

The City will make payment at the contract price for:

Item	Unit	Description
808	Each	Cut and Plug (Cap) ___ Inch Water Main or Water Tap
808	Each	Relocate ___ Inch Water Tap
808	Linear Foot	Relocate ___ Inch Water Main or Water Tap
808	Each	___ Inch Water Main Lowering
808	Each	___ Inch Water Main Abandoned
808	Each	___ Inch Water Tap Abandoned

ITEM 809 FIRE HYDRANTS

809.01 Scope of Work
809.02 Description of Fire Hydrants
809.03 Installation
809.04 Backfilling
809.05 Not Used
809.06 Hydrant Relocation
809.07 Hydrant Abandoned
809.08 Basis of Payment

809.01 Scope of Work. The Contractor shall furnish all labor, tools, material and equipment, and coordinate inspections necessary to furnish and install new fire hydrants at the locations shown on the plans or as ordered and specified.

The item shall include all excavation, furnishing and installing the new fire hydrant complete with all fittings, approved polyethylene wrap, backfilling and all other incidental work necessary to complete this item of work. The Contractor shall install hydrant watch valves and 6 inch ductile iron hydrant leads where necessary, under Items 801 and 802.

The Contractor shall notify the Division of Fire prior to taking any fire hydrant out of service. All hydrants, whether new or relocated, shall be inspected and approved by the Division of Fire prior to being put into service.

809.02 Description of Fire Hydrants. Provide post-type fire hydrants conforming in all respects to the American Water Works Association Standard for "Fire Hydrants for Ordinary Water Works Service", AWWA - C502 except as herein after specified.

1. **Type of Hydrant.** Provide a compression type hydrant with the valve opening with or against the pressure. Provide the stem or valve rod with the valve end constructed to eliminate contact of dissimilar metals in the presence of moisture. This construction to extend above the moisture line at valve.

Provide stems or valve rods made of 1-inch minimum steel stock before machine work between the valve and the operating nut. Locate a breaking coupling at the proper point to conform to the breaking connection in the standpipe.

Unless otherwise approved by the Administrator, Division of Water, provide fire hydrants for use in the City of Columbus in accordance with the current Approved Materials List.

2. **Design.** Design the hydrants to localize and concentrate stresses generated by a smashing blow at a predetermined point in the couplings, straining the metal at this point beyond its ultimate tensile strength before a similar condition develops in the adjacent sections of the standpipe and stem. Design the hydrant so that the upper and lower sections of the hydrant breaks apart cleanly without bending the stem and without damage to the working parts of the hydrant, or the abutting parts of the standpipe sections with no leaking or flooding.

Secure the upper section of the standpipe that carries the nozzle to the lower section so that the upper section revolves, thus permitting the relocation of the nozzle to any desired direction.

Design a hydrant repairable using simple tools and the minimum number of parts, without the necessity of excavating or shutting off the water supply to the hydrant, if the hydrant breaks at the joint. Design the hydrant with a stem and main valve removable through the top of the standpipe without excavating.

3. **Materials.** Provide a hydrant constructed of materials of the best commercial quality in their respective classes.

4. **Workmanship.** Provide clean and perfect castings with no plugs or patches. Provide parts true to gauge to ensure interchangeable parts from one hydrant to another of the same make and size. The City will reject and return hydrants not conforming to specifications to the Contractor at the Contractor's expense.

5. **Testing.** Provide hydrants properly assembled and tested before leaving the factory.

6. **Certification.** Provide certification that the hydrant manufacturer manufactured and tested the type hydrant furnished in accordance with these specifications.

7. **Paint.** Provide hydrants with two good coats in a gloss enamel of one color for the entire hydrant. The color shall be Safety Orange. After installation of the fire hydrants, the Contractor is responsible to apply touch-up paint to any damage to the factory-applied hydrant paint. Hydrants will not be accepted until any paint damage from shipping or installation has been repaired. Use hydrant touch-up paint in accordance with the approved material list.

8. **Valves.** Equip hydrants with rubber faced valves.

9. **Detailed Specifications, Size, Etc.**

Diameter of Port in Seal Ring:	Minimum 4 1/4 inches
Size and type of connection to Main:	6 inches hub or bell or mechanical joint
Depth of Trench or Bury:	5 feet unless otherwise specified or shown on the plans
Number of Nozzles - One (1):	Center Front
Inside diameter of nozzle:	4 inches
Dimensions of nozzles and threads:	4 27/32 inches outside
Diameter of male thread:	4 37/64 inches root of diameter; 6 threads per inch
Higbee cut. Length of thread:	1 1/4 inches right

10. **Hydrants to Open to the Right (Clockwise).** Size and shape of nozzle caps and operating nuts - 7/8 inch square at top, tapered to 1 inch) at bottom, by 1 1/4 inch high. Thread on stem and nut - U.S. Standard (left hand).

11. **Drips or Draining Devices.** Eliminate drips or draining devices.

12. **Pumper Nozzle.** Provide threaded or quarter-turn type pumper nozzles. For threaded type nozzles, provide the nozzle that screws into the standpipe with pipe threads.

13. **Breaking Connection.** Provide a breaking connection of a type approved by the Administrator of the Division of Water.

Exclusive of the main valve opening the cross sectional area available for water flow at any point of the waterway of the barrel or foot-piece of the smallest part shall not be less than 120 percent of that of the net opening of the main valve.

14. **Shop Drawings.** Before installing any hydrant under the jurisdiction of this specification, obtain approval of drawings of the proposed hydrant. Provide drawings in sufficient detail to enable checking design and material. Correct errors or omissions discovered and supply the hydrant in accordance with the specifications.

809.03 Installation. Furnish and install hydrants at the locations shown on the plans. Locate hydrants 2 feet behind the back of the curb line or 8 feet from the edge of paved area on non-curbed roadways unless otherwise shown on the plans or directed by the Engineer. Provide hydrants of the proper length to suit the depth of cover over the water mains at the locations shown on the plans and furnish the necessary extensions to obtain the proper length. Locate fire hydrants a minimum of 6 feet clear of all residential driveway openings and curb returns, and a minimum of 10 feet clear of all commercial driveway openings. Install and restrain a second watch valve within 2 feet of the hydrant if the hydrant lead exceeds 15 feet in length.

Excavate the pit or trench for the fire hydrant so when installed, the hydrant base rests on a minimum size 12-inch wide by 12-inch long by 2-inch thick paver on undisturbed soil. Set the hydrant plumb with nozzle outlet approximately 18 inches from ground line. Set hydrants in accordance with grade line or approximately 2 inches below bottom of break connection on the hydrant standpipe.

Install mechanical joint wedge action restraining glands at all joints on the fire hydrant lead and fire hydrant. Refer to Division of Water Standard Detail Drawings for details. If a joint is required on the hydrant lead, install a wedge-type bell restraint harness to provide joint restraint.

Any fire hydrant used between the dates of September 15th and April 15th shall be pumped dry to the foot valve of the hydrant barrel or a minimum of five (5) feet below the surface of the existing ground, by the Contractor, immediately after each time the hydrant is operated or after initial installation.

809.04 Backfilling. Backfill with granular material conforming to 304.02 or 703.11 or approved suitable excavated material, power tamped in layers not exceeding 4 inches in thickness, loose measurement. Extend the granular backfill from the bottom of the pit or trench to 6 inches below the existing or proposed surface of the surrounding area. Include the cost of furnishing and placing this backfill in the price bid per fire hydrant.

809.05 Not Used.

809.06 Hydrant Relocation. Relocate fire hydrants by removing the existing hydrant, installing new 6 inch ductile iron pipe and cast iron fittings as required to set hydrant at location and elevation shown on the plans, resetting hydrant, backing, and backfilling to complete the work. If the new hydrant lead exceeds 15 feet in length, install a second watch valve and restrain within 2 feet of the relocated hydrant. For relocations that parallel the right-of-way, if relocating more than 15 feet abandon the existing fire hydrant per 809.07 and add a new fire hydrant installed at the proposed location. All piping and/or fittings installed with the relocation, including hydrants, shall be tested at line pressure, visually inspected by the City for leakage, and hand swabbed with chlorine for disinfection.

809.07 Hydrant Abandoned. Where shown on the plans or directed by the Engineer, abandon fire hydrants as indicated by either removing the anchoring tee and installing a solid sleeve on the water main or installing a mechanical joint plug and concrete backing at the tee. Block in accordance with Standard Detail Drawing L-7001. Deliver abandoned hydrants to the Water Maintenance, 910 Dublin Road, Columbus, Ohio, unless otherwise directed by the Engineer. The City will make no additional payment for this delivery.

809.08 Basis of Payment. The City will pay for fire hydrants at the contract unit price bid for each hydrant installed or relocated, complete and ready for use, or for hydrant abandoned. The City will consider the unit price and payment as full compensation for doing all work and providing all materials above described. The City will pay for temporary pavement, permanent pavement and hydrant extensions under the appropriate items. The City will pay for the cost of the hydrant lead and watch valve under Items 801 and 802.

The City will make payment at the contract price for:

Item	Unit	Description
809	Each	Fire Hydrant
809	Each	Fire Hydrant, Relocated
809	Each	Fire Hydrant, Abandoned

ITEM 810 FURNISHING AND INSTALLING HYDRANT EXTENSIONS, COMPLETE

810.01 Description
810.02 Hydrant Extensions
810.03 Backfilling
810.04 Hydrant Lowering
810.05 Basis of Payment

810.01 Description. The Contractor shall furnish all labor, tools, materials and equipment necessary for furnishing and installing hydrant extensions, of the sizes shown in the proposal, where required or as directed by the Engineer.

810.02 Hydrant Extensions. Provide cast iron standpipe extensions meeting the requirements of the applicable sections of Item 809 regarding quality, painting, etc. Provide valve stem extensions of suitable length with couplings to fit those on hydrant valve stem. Provide hydrant extensions capable of insertion in the standpipe at the breakable section, and this section then moved to the upper end of the extension. Design all parts of the extension so that installation and removal can be accomplished with ordinary tools and without removing the hydrant valve or stem. Do not exceed a 24-inch maximum total height of extensions (existing and new). Unless otherwise approved by the Engineer, use no more than one extension on a hydrant assembly. Install the fire hydrant lead as specified on the Division of Water, Standard Detail Drawing L-7601 on water mains greater than seven (7) feet deep. The City will not permit installation of hydrant extensions with L-7601 unless otherwise approved by the Engineer.

810.03 Backfilling. Backfill around hydrant extensions in conformance with the requirements of 809.04.

810.04 Hydrant Lowering. Where adjusting existing hydrants equipped with extensions to the proper grade, remove extensions as needed. If hydrant is not equipped with an extension, lower hydrants in accordance with 809.06.

810.05 Basis of Payment. The City will pay for hydrant extensions or lowerings at the contract unit price bid per each for this item in the proposal. The City will consider the unit price bid payment as full compensation for all labor, tools, materials, equipment, and incidentals necessary to furnish and install (or remove) hydrant extensions, complete, as shown, ordered or specified.

Payment will be made at the contract price for:

Item	Unit	Description
810	Each	____ Inch Hydrant Extensions
810	Each	____ Inch Hydrant Lowering

ITEM 811 INCREASE OR DECREASE IN EXCAVATION AND BACKFILL

811.01 Description
811.02 Method of Measurement
811.03 Basis of Payment

811.01 Description. Under this item the Contractor shall, when and wherever ordered by the Engineer increase or decrease the trench depth and/or width from the elevations and/or alignment shown on the plans. This increase or decrease shall include any necessary compacted 801.11, 801.12 or Item 613 backfill material as required by the Engineer.

811.02 Method of Measurement. The City will consider the amount of increased or decreased excavation and backfill as the difference between the standard trench width and/or plan depth compared to the actual excavation required as ordered by the Engineer.

811.03 Basis of Payment. The City will pay for all work performed under this item at the unit price per cubic yard as bid and will consider the payment as full compensation for all labor, material and equipment specified or required. The City will apply a credit to the final quantity under this item at the unit price per cubic yard equal to the amount of unperformed excavation and backfill, as calculated in 811.02, for decreased amounts of excavation and backfill.

The City will make payment or a deduction at the contract price for:

Item	Unit	Description
811	Cubic Yards	Increase or Decrease in Excavation and Backfill

ITEM 812 AIR RELEASE OUTLETS

812.01 Description
812.02 Materials
812.03 Basis of Payment

812.01 Description. Under this item, the Contractor shall furnish all labor, materials and equipment necessary to furnish and install the air release outlets, of the size and, at the locations shown on the plans or as directed by the Engineer and in accordance with Standard Detail Drawing L-6473A or L-6473B.

812.02 Materials. Provide corporation stops with threaded inlets and copper pipe outlets from a product listed on the current Approved Materials List. Install corporation stops in the top quarter section of the water main.

Provide curb stops designed for use with copper tubing with compression type fittings.

Provide screw-type curb boxes with a 2 1/2 inch inside diameter adjustable in height from 42 inches to 60 inches with the word "WATER" cast neatly and legibly on the a lid held in place by a bronze or brass standard bolt. Provide curb boxes in accordance with the current Approved Materials List. Where installing curb boxes for the air release outlets within traveled areas, include a Columbus standard ferrule box and cover in the top section of the curb box.

812.03 Basis of Payment. The City will pay for all work under this item the unit bid price and will consider the payment as full compensation for labor, materials and equipment necessary to make a complete installation. The complete installation shall include the corporation stop, curb stop, curb box, ferrule box, copper tubing and fittings, excavation, and backfill.

The City will make payment at the contract price for:

Item	Unit	Description
812	Each	_____ Inch Air Release Outlet

ITEM 815 CRUSHED STONE OR GRAVEL

815.01 Description
815.02 Crushed Stone or Gravel
815.03 Construction
815.04 Method of Measurement
815.05 Basis of Payment

815.01 Description. The Contractor shall place crushed stone or gravel for backfill or trench topping under this item wherever shown or ordered by the Engineer and the Contractor shall furnish all labor, material, tools and equipment necessary to spread, roll or tamp the crushed stone or gravel. The Contractor shall treat the surface with calcium chloride when using crushed stone or gravel as trench topping, and shall maintain the trench topping where ordered and as specified, until final restoration.

815.02 Crushed Stone or Gravel. Provide 100 percent crushed stone or gravel graded in accordance with 304.02.

815.03 Construction. Furnish and place crushed stone or gravel specified or ordered by the Engineer as trench topping, over the full width of the excavated space from the top of the backfill up to the surface of the adjoining pavement. Where backfilling with acceptable natural soil and placing trench topping as required or ordered, place topping over the designated area to a depth of 3 inches. Provide trench topping material that conforms to the surface of the adjacent pavement or area. Immediately dust proof the finished surface by treating with calcium chloride and repeat the treatment as required to alleviate the dust or as ordered by the Engineer. Refill settlement or irregularities that occur in the trench topping before final restoration with crushed stone or gravel and compacted and treated as specified above.

In areas where the Engineer orders temporary bituminous topping, provide and place crushed stone or gravel trench topping as specified above. The trench topping will not require dust proofing. Do not extend trench topping above a level 2 inches below the adjacent undisturbed pavement.

815.04 Method of Measurement. The City will pay for crushed stone or gravel used as water main trench topping under this item measured on the basis of 4000 pounds per cubic yard, multiplied by the actual volume of the trench topping placed. In no case will the City pay for trench topping placed beyond the limiting lines shown for excavation, unless the Engineer specifically ordered such work.

815.05 Basis of Payment. The City will consider the price bid per cubic yard for crushed stone or gravel under this item as including furnishing of all labor, material, tools and equipment necessary to place and maintain the material as trench topping as specified or ordered.

The City will make payment at the contract price for:

Item	Unit	Description
815	Cubic Yard	Crushed Stone or Gravel

900 SEWERAGE WORK

ITEM 901 PIPE SEWERS COMPLETE IN PLACE

901.01 Description
901.02 Materials and Material Handling
901.03 Excavation
901.04 Limit as to Width of Trench
901.05 Unauthorized Excavation
901.06 Subgrade
901.07 Excavation Material
901.08 Removal of Obstructions
901.09 Maintaining Drainage
901.10 Maintenance of Service in Existing Structures
901.11 Bedding and Embedment
901.12 Laying Pipe
901.13 Bulkheads
901.14 Sanitary Sewers
901.15 Pipe Joints
901.16 Removal and Disposal of Water
901.17 Backfilling
901.18 Surface Soil and Restoration of Surfaces
901.19 Trees
901.20 Leakage Tests
901.21 Deflection
901.22 Method of Measurement
901.23 Basis of Payment

901.01 Description. This work consists of the construction of pipe sewers complete in place in accordance with these specifications and in conformity with the lines and grades shown on the plans, or as established by the Engineer. This work includes: excavating for pipes and pipe bedding, clearing and grubbing, fill or embankment, and the removal of all materials necessary for placing the pipe except removals listed separately; furnishing and placing concrete or granular bedding, concrete backing or encasement, and compacted backfill, granular backfill, compacted granular backfill or concrete backfill as required; placing trench dams; constructing and subsequently removing all necessary cofferdams, cribs and sheeting; constructing and placing all necessary bulkheads; removal of water; installing all pipe joints; furnishing, installing and testing all necessary pipe of the types specified or shown on the plans; joining to existing and proposed sewers and appurtenances as required; restoration of disturbed facilities and surfaces; maintenance of traffic, drainage and existing facilities all as shown on the drawings and as specified, unless otherwise provided for by separate pay items. The City will specify and pay for structures under Item 604.

901.02 Materials and Material Handling. Provide pipe of the size and kind specified in the proposal and shown on the plans and meeting the requirements of the relevant parts of Item 706, Item 720 or Item 801. If the proposal or plans do not specifically itemize the type of pipe, the Contractor may use pipe from the City of Columbus Approved Producers/Products List.

Provide specific materials as follows unless otherwise specified in the Contract Documents:

1. Concrete for encasement, cradle, backing and backfill Class COC 8 ..... 499, 905
2. Concrete for blocking - Class COC 6 499
3. Stone or gravel bedding - No. 57 703
4. Compacted granular material 912.02
5. Cement for mortar 701
6. Sand for mortar 703.03
7. Lime for mortar 712.04
8. Gaskets for Concrete Pipe Joints 901.15
9. Gaskets for Vitrified Clay Pipe Joints 901.15
10. Gaskets for PVC Pipe Joints 901.15
11. Gaskets for Ductile Iron Pipe Joints 901.15

Rigid Pipe

12. Non-Reinforced Concrete Pipe 706.01
13. Reinforced Concrete Pipe 706.02
14. Elliptical Reinforced Concrete Pipe 706.04
15. Vitrified Clay Pipe, Extra Strength 706.08
16. Precast Reinforced Concrete Box Sections 706.05

Flexible Pipe

17. Polyvinyl Chloride (PVC) Sewer Pipe 720

18. Ductile Iron Pipe 801.03
19. High Density Polyethylene Pipe (HDPE) 720
20. High Density Polypropylene Pipe (HDPP) 720
21. Glass-Fiber-Reinforced Polymer Mortar Pipe..... 720
22. Polyvinyl Chloride (PVC) C 900 and C 905 Pipe. 720

Exercise care in material handling to prevent field and installation damage that could impair the function and durability of the installation. In particular, carefully handle thermoplastic conduits during cold weather.

901.03 Excavation. Excavate all material of whatever nature encountered, including rock in place, as defined in Item 903, except for rock excavation as specified separately, made necessary for the construction of work as shown on the Standard Drawings or plans and as specified. Provide open trench excavations, except as otherwise required, permitted or ordered in writing by the Engineer.

Sawcut all existing pavements, walkways, curbs, etc. before removal. If during construction, the Contractor damages pavements, walkway, curb, etc. beyond the original saw cut, recut the damaged area to neat lines as directed by the Engineer. Include the cost of saw cutting in the items of the contract and the City will not pay separately.

901.04 Limit as to Width of Trench. Do not exceed the specified width of trench below the elevation of the outside top of the barrel of the sewer as shown on the Standard Drawings, unless included on the plans or permitted in writing by the Engineer. Provide, install, and use sufficient sheeting, bracing, timbering, etc., to maintain the sides of the trench in a substantially vertical position; and, in such a manner to protect and preserve, life, property or the use of such property. The City will not pay separately for such sheeting, bracing, timbering, etc. necessitated by the Contractor's operations to accomplish and carry out this responsibility.

For sewer installations within an embankment or for sewers above existing ground, construct the embankment, in accordance with Item 203 requirements, at least to 30 inches above the outside top of the sewer pipe before trenching. Then excavate the trench to the minimum width necessary for proper placing and backfilling of the sewer as described in 901.17.

For installation of thermoplastic pipe, excavate the trench in accordance with the Standard Drawings or ASTM D2321, 6.1 through 6.5 where more restrictive than set forth above.

901.05 Unauthorized Excavation. The Engineer will classify as unauthorized excavation all excavation outside or below the limiting lines for bedding as shown on the Standard Drawings. Fill with material and in a manner approved by the Engineer at no additional cost to the City.

901.06 Subgrade. The City expects the Contractor will find satisfactory material at the subgrade of the trench if the Contractor performs adequate water removal. If the Contractor encounters soft, spongy, unsuitable or similarly unacceptable material at the bedding subgrade, remove this unsuitable material as directed by the Engineer in writing. The following will govern the prosecution of the work directed by the Engineer.

1. If Contractor dewatering of the subgrade materials in accordance with 901.16, produces a subgrade acceptable to the Engineer for placing the bedding material, the City will not make additional payment for the work.
2. After dewatering of subgrade materials in accordance with 901.16, for unsuitable material removed by written order of the Engineer, replace with a stone foundation as specified in Item 906 and paid for as indicated therein.

901.07 Excavation Material. Dispose of all excavated material in excess of that required for backfilling. Do not use public or private property for this purpose without the written permission of the Owner. The Contractor may store excavated material required for backfill, except as provided for under Surface Soil as per 901.18, on the bank of the trench in accordance with applicable safety and environmental regulations where space is available within the right-of-way acquired for the work. Do not interfere with the access to and maintenance of traffic, drainage and utilities as herein specified.

Secure the Engineer’s approval of the location of an off-site disposal area before using.

Maintain ingress and egress to all properties along the line of the work, except as permitted, in writing, by the Engineer.

901.08 Removal of Obstructions. Remove any obstructions, including abandoned sewers or water lines, encountered or necessary for the construction of the work at no additional cost to the City, except as provided in 104.02.B, if applicable.

For existing pipes encountered in removal operations that are determined inactive by the Engineer, fill and plug or seal at both ends where broken.

For abandoned and removed portions of an existing concrete or clay sewer under this Contract, construct brick or concrete bulkheads in the undisturbed section of the abandoned sewer as directed by the Engineer. The drawings may or may not show the locations of bulkheads. For abandoning existing sewer made of a material other than clay, brick or concrete, cap or plug the undisturbed section as directed. The cost of this work is included in the various items of the Contract and the City will not make a separate payment, unless a separate pay item is specified.

901.09 Maintaining Drainage. Maintain the flow of all sewers, drains, streets, gutters, field tiles and watercourses encountered at no additional cost to the City. Restore to a condition satisfactory to the Engineer and applicable jurisdictional authority any watercourses and drains disturbed or destroyed during the prosecution of the work at no additional cost to the City.

901.10 Maintenance of Service in Existing Structures. Maintain in service all existing overhead, surface or subsurface structures, together with all appurtenances and service connections, except those otherwise provided for herein, encountered or affected in any way during the construction of any of the work under this contract at all times, unless the Contractor makes other arrangements, satisfactory to the authority responsible for their operation.

For connections made to existing sewers, make suitable provisions for maintaining the flow in the existing sewer until the completion of the connection.

Include the cost of this work in the prices bid for all the various items of the contract.

901.11 Bedding and Embedment. Place cutoff trench dams of native clay or impervious soil across and along the trench at 150 foot intervals. Place at least 1 trench dam between adjacent manholes regardless of spacing. Compact the trench dams 6 feet in length, as measured along the sewer centerline and bench into the undisturbed trench sides from the subgrade or top of cradle, to within 5 feet of the existing surface. If constructing trench dams in rock or hardpan, extend to the top thereof whichever is greater. Where pipe cover is less than 5 feet, extend the dam to within 1 foot of the existing surface. Provide the trench dam installation with a minimum of 3 feet of compacted material above the crown of the pipe.

Type I.

1. For flexible sanitary and storm sewers 6 inches in diameter up to and including 60 inches in diameter, provide a bedding of No. 57 stone, conforming to 703.08, extending from a point 4 inches below the bottom of the pipe to a point 6 inches above the outside top of pipe as shown on the Standard Drawings.
2. For rigid sanitary and storm sewers 6 inches in diameter up to and including 27 inches in diameter, provide a bedding of No. 57 stone, conforming to 703.08, extending from a point 4 inches below the bottom of the pipe to spring line of the pipe as shown on the Standard Drawings.
3. For rigid sanitary and storm sewers 30 inches in diameter up to and including 108 inches in diameter, provide a bedding of No. 57 stone, conforming to 703.08, extending from a point 6 inches below the bottom of the pipe to the spring line of the pipe as shown on the Standard Drawings.

If using Type I bedding, include the cost of all bedding as described above in the price bid for the various pipe items.

Provide embedment for thermoplastic pipe in accordance with the recommendations of ASTM D2321, 7.5.

Type II.

Set sanitary and storm sewers to line and grade on Class COC 6 Concrete Blocking meeting the following minimum requirements:

1. Provide concrete blocking with a horizontal bearing area in contact with the subgrade creating the bearing load not exceeding 3,000 pounds per square foot.
2. Provide concrete blocking that supports the pipe at least 6 inches above the subgrade.
3. Allow concrete to remain exposed until completion of the initial set.

Construct a Class COC 8 Concrete Cradle to fill all the space around the concrete blocking and below the pipe as shown on the Standard Drawings. The City will deem all concrete placed outside the limiting lines for trench width and elevation as unauthorized and will not include for payment. Provide backing of stone bedding or compacted granular material as described in Type I bedding unless Class COC 8 Concrete is specified, or shown on the drawings.

For Type II bedding, include the cost of all bedding as described above in the price bid for the various pipe items.

Fill all the space within the width of the trench excavation, inside or outside the authorized limits and between the elevation limits, with the same material as specified on the applicable Standard Drawing.

901.12 Laying Pipe. Examine each pipe for defects and damage. Do not use defective or damaged pipe. Lay pipelines to the grades and alignment indicated. Provide proper facilities for lowering sections of pipe into trenches. Do not, under any circumstances lay pipe in water or when trench conditions or weather prove unsuitable for such work. Provide for the diversion of drainage or dewatering of trenches during construction as necessary. Inspect all pipe in place before backfilling, and remove and replace those pipes damaged during placement.

Lay pipes in finished trenches starting at the lowest point so that the spigot ends point in the direction of flow. Lay all pipes with ends abutting and true to line and grade.

Where necessary with bell end pipe, excavate suitable bell-holes in the bedding material for the bell of each pipe so that the bells will not support the weight of the pipe. Fit and match the pipes so that when placed, they will form a conduit with a smooth and uniform invert. Use all possible care when shoving the pipes together to minimize the joints and carefully clean the pipe ends before placing the pipes. Install gaskets in accordance with the manufacturer's recommendations.

Use Class COC 8 concrete encasement, in accordance with the applicable dimensional Standard Drawing, within the limits of existing or proposed paved areas inside right-of-way where minimum cover during construction or proposed cover over the outside top of the pipe to top of finished grade is 36 inches or less.

Make all connections with existing structures after cleaning the structures in a thorough, first class, neat and workmanlike manner acceptable to the Engineer. Include the cost of this work in the price bid for the various pipe items.

901.13 Bulkheads. Construct a bulkhead at the start of construction of Sanitary Sewers, and remove same bulkhead after placing all pipes and manholes, removing all water, testing the sewer, and receiving approval from the City.

Seal the outer ends of all concrete, brick or clay pipe stubs with a brick masonry bulkhead. Construct bulkheads 8 inches thick for stubs 21 inches and larger in diameter, and 4 inches thick for stubs smaller than 21 inches in diameter. Plaster all bulkheads with a 1/2 inch coat of mortar. Include the cost of this work in the price bid for various pipe items.

Plug or cap all thermoplastic pipe stubs in a manner acceptable to the Engineer using a fitting as approved by the pipe manufacturer.

901.14 Sanitary Sewers. Do not connect roof drains, foundation drains and other clean water connections to sanitary sewers.

901.15 Pipe Joints.

A. Sanitary Sewers

1. Concrete. Provide pipe joints conforming to the requirements of ASTM C 443 and as specified herein. Use solid gaskets of circular or tapered cross section either confined in an annular space or step formed by the shoulder on the bell and spigot or in the groove in the spigot of the pipe so that movement of the pipe or hydrostatic and hydrodynamic pressure cannot displace the gasket. When the joint is assembled, compress the gasket to form a watertight seal.

Provide all elliptical reinforced concrete pipe for sanitary sewers with Type B - mortar joints and ASTM C 877 rubber and mastic sealing band.

2. Vitrified Clay. Provide pipe joints conforming to the requirements of ASTM C 425 Compression Joints for Vitrified Clay Bell and Spigot Pipe.

3. Type PSM Poly Vinyl Chloride (PVC) Sewer Pipe. Provide pipe joints conforming to the requirements of ASTM D 3212.

4. Ductile Iron. Use mechanical or push on joints meeting AWWA C111 or restrained joints meeting AWWA C110 or C153.

5. Polypropylene Sewer Pipe. Provide pipe joints conforming to the requirements of ASTM D 3212.

6. Glass-Fiber-Reinforced Polymer Mortar Pipe. Provide pipe joints conforming to the requirements of ASTM D4161.

B. Storm Sewers

1. Concrete. Use pipe joints conforming to one of the following:

a. Type A Rubber Gasket. Meet the requirements of ASTM C 443.

b. Type B Mortar. On sewers 30 inches in diameter and larger, lay the groove end of the pipe to line and grade and wash with a wet brush and butter the bottom half of the groove with 1 to 2 Portland Cement mortar. Clean the tongue of the next section of pipe with a wet brush and apply a layer of 1 to 2 Portland Cement mortar to the top half of it. Then fit the tongue end of the second pipe into the groove end of the first pipe until the mortar is squeezed out onto the inner and outer surfaces. Point the inner surface of the pipe at the joint and smooth with a long handled brush. Point the outside with a bead of mortar. If the joint opening on the bottom half of the pipe exceeds 1/2 inch, fill with 1 to 2 Portland Cement mortar.

c. Type C Bituminous pipe joint filler. Meet the requirements of 706.10.

d. Type D Preformed butyl rubber material. Meet the requirements of 706.14. For concrete pipe 78 inch diameter and over, prime the annular mating surfaces

2. Vitrified Clay. Construct pipe joints conforming to one of the following:

a. Type A Compression. Meet the requirements for vitrified clay pipe joints used in sanitary sewers as specified herein.

b. Type C Bituminous filler. Meet the requirements of 706.10.

c. Type D Preformed butyl rubber material. Meeting the requirements of 706.14.

3. High Density Polyethylene/Polypropylene. Construct pipe joints conforming to one of the following:

a. Type A pipe joints. Meet the requirements of ASTM D 3212.

b. Type B pipe joints. Meet the requirements of AASHTO M-252, M-294, and Section 23 of the Standard Specification for Highway Bridges, Division II. Construct joints "silt tight" with bell and spigot connection. Provide bells either integrally joined to the pipe, or with separate sleeves (double-belled) designed to join the pipe in the field. The Contractor may use split couplings or separate sleeves to make field repairs.

4. Elliptical Reinforced Concrete Pipe. For all elliptical reinforced concrete pipe for storm sewers, use Type B mortar per 901.15.B.1.b, or Type C Bituminous pipe joint filler per 901.15.B.1.c. Where conditions dictate the use of other types of joints, the City will note such on the plans.

5. Glass-Fiber-Reinforced Polymer Mortar Pipe. Provide pipe joints conforming to the requirements of ASTM D4161.

C. Point Repairs. The Contractor may use preformed shielded rubber coupling rings in accordance with the current City of Columbus Approved Producers/Products List, when performing field repairs on both rigid and flexible pipes for both sanitary and storm sewer applications. Ensure the rubber sleeve and steel bands make a tight seal capable of meeting the leakage requirements as specified in 901.20. Use preformed shielded rubber coupling rings only to join pipe of similar material. Perform all installations of the preformed shielded rubber coupling ring in conjunction with the City of Columbus Standard Drawings.

When connecting pipes of dissimilar materials, use the type of coupler specifically manufactured for making the connection between said materials (i.e. concrete to clay, clay to plastic, etc.). Complete the repair by removing the existing pipe to the nearest structurally sound joint and install the new pipe in accordance with all applicable sections of Item 901. Sawcut existing pipe in a neat workmanlike manner, making the cut perpendicular to the longitudinal axis of the pipe. Include the cost of this work in the price bid for the various pipe items, unless directed otherwise by the Engineer.

901.16 Removal and Disposal of Water. During construction, provide proper and satisfactory means and devices for the removal and disposal of all water entering the excavations and remove all such water as fast as it collects to prevent interference with the prosecution of the work. Dispose of water in accordance with applicable erosion and sediment control requirements.

901.17 Backfilling. Backfill all trenches and excavations immediately upon the completion of the work, or as otherwise approved by the Engineer.

For rigid pipe sizes 6 inches to and including 108 inches in diameter, select and place backfill using finely divided job excavated earth that is free from debris, organic or frozen material and stones larger than 2 inches in their greatest dimension, from the top of the granular bedding or concrete backing, as shown on the Standard Drawing, to a level not lower than 12 inches above the outside top of the pipe.

Place the selected backfill layer above the crown of the pipe in lifts of 6 inches or less, unless otherwise approved by the Engineer. Carefully tamp the backfill in order to produce a cushion over the pipe to prevent its breakage during the placing of the remaining trench backfill material. The Contractor may use granular bedding material for the selected backfill layer, at no additional cost to the City.

When earth backfilling open trench excavations, use the best excavated earth, free from rubbish, and excessive frozen material. The Contractor may deposit occasional boulders or stones not larger than 1 cubic foot at least 2 feet above the top of the sewer, subject to the approval of the Engineer.

Where the contract requires concrete cradle, encasement or backing, allow at least 2 hours or sufficient time for initial set to elapse before placing granular backing, pipe protection or backfill. Employ a method for depositing the backfill to prevent damage to the sewer or other structures. Do not backfill concrete structures built in place until approved by the Engineer.

Where cradling, encasing or backing ductile iron sewer pipe, wrap the pipe the length of the encasement and at least 30 feet beyond both ends of the concrete applied.

Where cradling and/or encasing thermoplastic pipe in concrete, the length of the encasement shall extend from manhole to manhole for the encased section of pipe.

Except where the plans note other requirements, or provided for in the specifications, or directed by the Engineer, provide material for all open trench backfill above the elevation of the bedding material of the sewer having the same as or better soils characteristics than the adjacent undisturbed soil or materials, subject to other provisions of the specifications for compaction or special fill, in a manner satisfactory to the Engineer. Perform all backfilling operations and placement of the backfill material by such means to eliminate damage to the sewer, its appurtenant structures, and other adjacent structures.

Backfill all trenches that cross existing or proposed pavement (including berm) or where the front face of trenches, paralleling the pavement, is within 36 inches of the face of curb or edge of pavement (including berm) with compacted granular material. Compact other areas outside the above requirement, but inside the right-of-way, in accordance with the Standard Drawings.

Where sewer construction is in existing lawn areas outside proposed or existing right-of-way, compact the backfill to a minimum 90 percent maximum dry density.

Backfill or securely plate all trenches within the road right of way during non-working hours.

Exercise care during backfilling and compaction to avoid displacement of or injury to pipe. Movement of construction machinery over a pipe at any stage of construction shall be at the Contractor's own risk. Repair or replace any damaged pipe at no additional cost to the City.

Refill any settlement in the open trench backfill taking place within the guarantee period with satisfactory materials and repair the affected surface at no additional cost to the City.

901.18 Surface Soil and Restoration of Surfaces. Before starting trench excavation, remove the surface soil to a depth of not less than that of the topsoil material to a maximum of 12 inches below the original surface of the ground within the excavation limits, except where otherwise specifically exempted or provided. Segregate and store surface soil separately from the remaining stored excavated material. In cultivated areas, strip the entire work area, including storage areas for backfill, up to 12 inches deep and store for reuse. If necessary, acquire additional area to provide for such separate storage of surface soil. After the completion of sewer construction and basic trench backfill, place a minimum of 4 inches of suitable surface soil within the construction limits up to a depth of not less than that of the original topsoil, or a maximum of 12 inches. Allow for adequate surface soil thickness and leveling in embankments and re-excavate the basic trench backfill if necessary to allow for the surface soil fill. Provide final grades conforming to those shown on the plans. Obtain the surface soil for this requirement during initial trench excavation or furnish from other sources at no additional cost to the City.

Perform restoration of all surfaces as the work progresses and cease excavation and pipe laying until such restoration work is accomplished, as directed by the Engineer. In locations where surface soil is replaced and settlement below the original ground surface occurs within the guarantee period, refill with surface soil equivalent to the original material. Include the cost of all work and other expenses connected with the surface soil operation in the Contract Price for the various sewer items. The City will not pay separately.

Replace all surfaces, including grass or lawn, pavement, sidewalk, curbing and other surfaces disturbed or destroyed during and as a result of the construction of the work.

Seed all areas disturbed in accordance with the requirements of this section, unless otherwise stated on the plans. Perform the seeding operation in conformance with the requirements set forth under Item 659, within 30 days weather permitting.

Repair or replace all fences damaged or removed in connection with the construction of the sewer to the satisfaction of the Engineer. If necessary, provide temporary fencing.

Include in the prices bid for the sewer items, the cost of all such restoration in all areas involved above and adjacent to the work. The City will not pay separately unless specifically provided for under other items.

901.19 Trees. The Contractor may remove all branches or growth from trees the plans call for saving that interfere with the free construction of the pipe sewer, in accordance with Item 666 and at the direction of the Engineer. Include the cost of all work and expenses connected with the removal of branches in the price bid for the various sewer items. The City will not pay separately.

901.20 Leakage Tests. Acceptance testing of all sanitary sewers shall require a 30 day waiting period from the date of final backfilling. This shall include all laterals installed as part of mainline construction. Do not exceed the allowable limits of leakage for all completed and installed sanitary and storm sewer pipe as follows:

Sanitary Sewers	100 gallons per inch of tributary pipe diameter per 24 hours per mile of length or the computed equivalent for shorter lengths and shorter periods of time. Test all sanitary sewers.
Storm Sewers	1,000 gallons per inch of tributary pipe diameter per 24 hours per mile of length or the computed equivalent for shorter lengths and shorter periods of time. Perform tests on storm sewers only using the infiltration method and only if indicated on the plans.

Perform leakage tests after the deflection tests for flexible sewer pipe applications.

Perform the following leakage tests after cleaning all installed pipe and manholes and removing obstructions:

1. **Infiltration Test.** Conduct this test when the height of the ground water table is two feet or more above the elevation of the inside crown of pipe at the upstream limit of the tested section. Perform the infiltration test by installing a weir or other measuring device approved by the Engineer in the lower end of the sewer tested section. Measure the quantity of ground water infiltration into the sewer Do not exceed the allowable leakage.

2. **Exfiltration Test.** Conduct this test when the height of the ground water table is less than two feet above the elevation of the inside crown of pipe at the upstream limit of the tested section. Unless otherwise directed by the Engineer or indicated on the plans, perform testing section by section where a section consists of the distance between the successive manholes. Close the inlet ends of the upstream and downstream manholes with watertight bulkheads. Fill with water the sewer and the upstream manhole until the elevation of the water in the upstream manhole is two feet higher than the inside crown of the pipe in the tested, or two feet above the existing ground water in the trench, whichever is the higher elevation. The Contractor may fill and maintain full of water the length of tested section for a period of approximately 24 hours prior to the start of the test. If the water level in the upper manhole drops during this 24 hour period, raise the level to the test elevation mark before measuring the leakage. If performing the test at any time during the 24 hour period, set the water at the test elevation mark and perform the test.

Determine the exfiltration by measuring the volume of water added to return the surface of the water in the upstream manhole to the test elevation mark. Use a test period of at least 1 hour duration from the start of the test.

After the completion of the exfiltration test, the Engineer may order the test section drained and measurement of infiltration from existing ground conditions within three hours by means of a weir located in the downstream manhole.

The allowable leakage is based on a maximum difference in elevation of 8 feet between the level of water in the upper manhole and the invert of the bulkheaded pipe at the downstream manhole. If the difference in elevation exceeds 8 feet, increase the allowable leakage five percent for each 1 foot in excess of 8 feet.

3. **Manhole Test.** Test manholes by plugging connecting pipes and filling with water to 2 feet above the crown of the highest entering pipe. Fill the manhole and let stand for 24 hours. A passing test requires no loss of water in a 4 hour period. As an alternative to this test procedure, and if approved by the Engineer, the Contractor may perform a vacuum test in accordance with the procedures set forth in ASTM-C-1244.

4. **Air Test.** In lieu of exfiltration tests required for pipe sizes 8 inches through 24 inches under 901.20 (b) and if approved by the Engineer, the Contractor may request an air test for checking tightness of sanitary sewer pipe construction. Test all sections of pipe between manholes.

Air test pipes using equipment approved by the Engineer and in accordance with the following steps:

a. Plug all pipe outlets with suitable test plugs. Brace each plug securely.

b. Add air slowly to the portion of the pipe installation under test until the internal air pressure is raised to 4.0 psig.

c. After obtaining an internal pressure of 4.0 psig, allow at least 2 minutes for air temperature to stabilize, adding only the amount of air required to maintain pressure.

d. When pressure decreases to 3.5 psig, start stop-watch. Determine the time in seconds required for the internal air pressure to reach 2.5 psig. Use minimum permissible pressure holding times for runs of single pipe diameter and for systems of 6 inches or 8 inches laterals in combination with trunk lines published in the current tables of the National Clay Pipe Institute for vitrified clay pipe, ASTM C-1103 for concrete pipe, or Table 1 in UNI-B-6-** by Uni-Bell PVC Pipe Association for PVC pipe and GFRP pipe.

If the leakage exceeds the allowable limits, determine the location where excess water is entering or leaving the sewer. Replace or repair the sewer and/or manholes with materials approved by the Engineer. Retest until the leakage is within the allowable limits. Include, in the price bid per linear foot of sewer, the cost of all bulkheads, plugs, pipe stopper, pumps, compressors, water, weirs, labor, delay, and any other items of cost necessary for the performance and completion of the required leakage test and for the cost of any repairs or adjustments necessary to conform to the required allowable leakage limits.

Conduct all leakage tests in the presence of the Engineer.

901.21 Deflection. Before final acceptance of completed flexible sewer lines by the Engineer, perform a pipe deflection test on all main line sanitary sewers and storm sewers where required at no additional cost to the City.

Measure all lines for vertical ring deflection no sooner than 30 days after completion of backfilling operations, if sufficient settlement of the backfill has occurred, as determined by the Engineer. The Engineer's determination of sufficient settlement is final.

Do not exceed the maximum limit of vertical deflection of 5 percent. Calculate the 5 percent using the applicable ASTM or AASHTO procedures. Testing shall be in accordance with 901.21.A unless upstream or downstream access is not available. In that case, testing shall be in accordance with 901.21.B.

A. Mandrel. Perform the test by manually pulling a City of Columbus approved "go, no-go" mandrel with 9 arms.

B. Crawler Mounted Camera with Laser Profiler. Provide a crawler mounted video camera with laser profiler, rotating laser or laser ring capable of measuring and recording the identification, location, and description of the conduit condition with all equipment necessary to perform the inspection that meets all the requirements listed in 1 through 6 below.

Provide a letter of certification to the Engineer from an independent testing facility stating that the crawler mounted camera with laser profiler meets all the requirements listed herein.

1. Provide a crawler that meets the following requirements:

a. Capable of inspecting conduits ranging in size from 8 to 120 inches.

b. All-wheel drive or track-mounted.

c. Adjustable camera height such that the camera can be centered in the conduit vertically and horizontally.

d. Crawler does not obstruct the camera's view or interfere with proper recording of the conduit condition.

e. Crawler speed is adjustable with an operating speed while recording not to exceed 30 feet per minute.

2. Provide a video camera that meets the following requirements:

a. Zoom ratio of at least 40:1. Can be achieved with a combination of optical and digital zoom, however the optical zoom ratio must be at least 10:1.

b. Light source that allows all areas of concern to be readily observed.

c. Capable of 360 degree rotation as well as pan and tilt to a 90 degree angle to the axis of the conduit.

3. Provide laser profiler that meets the following requirements:

a. Capable of measuring the actual deformities with at least 0.50 percent precision when tested at 30 feet per minute. Measurements must be taken at least 30 times per second as the laser profiler moves through the conduit.

b. Profiles conduit ranging in size from 8 to 120 inches.

c. Conduit deflection must be calculated from the actual interior diameter or by inputting the nominal diameter.

d. All measurements must be taken and recorded automatically and be unable to be manually input or modified.

e. Provide a repeatability of 0.12 percent or better.

4. Calibrate the laser profiling measuring equipment according to ASTM E691 and ASTM E177 and provide written certification from an independent testing facility that it meets the above requirements. Recalibrate the equipment if the laser profiler or camera are modified or repaired.

An independent testing facility must certify that the equipment will meet performance requirements under normal operating conditions (not just in a controlled environment).

5. Provide a crack and defect measuring tool that meets the following requirements:

a. Measurement accuracy of at least 1/32 inch for defects one inch or smaller, and at least 3/32 inch for defects larger than one inch.

b. Shows a calibration procedure on the video display at every measurement.

c. Demonstrate during every measurement that the video micrometer and camera lens is positioned perpendicular to the defect or joint being measured.

6. Provide a recording device that is capable of recording video with the conduit identification, location and type shown on the video. Furnish the video recording in MPEG2 format at a resolution of 720 × 480 on one of the following media types: DVD, CD or other media type approved by the City.

Provide all equipment and labor needed to perform and conduct the required test. Notify the Engineer at least 48 hours in advance of the anticipated date of the testing to schedule personnel needed to monitor the testing operations.

In areas where deflections exceed the 5 percent limit, correct the problem area(s) at no additional cost to the City. Where correction is required, the City will pre-approved one of the following procedures for the Contractor to utilize:

1. Re-excavate the trench, and remove and replace the backfill and pipe in accordance with the original plans and specifications. If, in the opinion of the Engineer, the Contractor has damaged the pipe, replace the pipe with new pipe and install per the plans and specifications. Retest the failed sections of pipe corrected by this method in accordance with 901.21 no sooner than 30 days after the correction is made or as otherwise directed by the Engineer.

2. Re-round the failed section(s) using an approved company providing this service. Submit methods, types of equipment, and company to provide service in writing to the Engineer for approval 5 working days before performing this procedure. Use this method only if approved by the Engineer and the deflection has not exceeded 10 percent of the base inside diameter of the pipe. Determine the deflection by pulling a 9 arm "go, no-go" mandrel having a diameter equal to 90 percent of the base inside diameter of the pipe.

After completing either procedure 1 or 2, retest the repaired area(s) in accordance with 901.20 and 901.21 before final acceptance.

901.22 Method of Measurement. The Engineer will measure and accept the length of pipe by the linear feet, as measured along the centerline of the sewer, complete in place, including lengths to the center of manholes, inlets, and tunnel shafts. For an extended stub or branch stub at a manhole, if more than one length of pipe extends beyond the wall of a manhole, the Engineer will measure from the center of the manhole to the end of the stub, unless the payment for such stub is otherwise provided.

901.23 Basis of Payment. The City will pay accepted quantities of sewer of the sizes and types specified at the contract unit prices per linear foot, complete in place.

The City will pay under:

Item	Unit	Description
901	Linear Foot	____ inch (Sanitary or Storm) Pipe, with Type ____ Bedding
901	Linear Foot	____ inch (Sanitary or Storm) Pipe, with Type ____ Bedding, with Item 911 Compacted Backfill
901	Linear Foot	____ inch (Sanitary or Storm) Pipe, with Type ____ Bedding, with Item 912 Compacted Granular Material

ITEM 902 INCREASED OR DECREASED EARTH EXCAVATION

902.01 Description
902.02 Excavation and Backfilling
902.03 Method of Measurement
902.04 Basis of Payment

902.01 Description. This work consists of performance or non-performance of excavation, and backfilling with suitable material, for sewers or other appurtenant structures, where ordered by the Engineer, due to deviation from the line and grades shown on the plans. This item includes removal of excess excavated material from the site as required.

902.02 Excavation and Backfilling. The applicable sections of 901.03 and 901.17 will govern this work unless otherwise specified or directed in writing.

902.03 Method of Measurement. The Engineer will measure and accept the number of cubic yards of increased or decreased earth excavation vertically below or above the structure subgrade and with limits to the vertical planes of 12 inches outside of the structure surfaces. The Engineer will measure the number of cubic yards of increased earth excavation due to deviation from the line and grade shown on the plans by multiplying the total length of trench involved by the product of the trench width as shown in the plans and the average depth of increase or decrease involved.

902.04 Basis of Payment. The City will pay accepted quantities of increased or deduct accepted quantities of decreased earth excavation ordered in writing by the Engineer at the contract unit price per cubic yard.

The City will pay or deduct under:

Item	Unit	Description
902	Cubic Yard	Increased or Decreased Earth Excavation

ITEM 903 ROCK EXCAVATION

903.01 Description
903.02 Blasting
903.03 Estimated Quantities
903.04 Method of Measurement
903.05 Basis of Payment

903.01 Description. This work consists of furnishing all labor, equipment and materials for removing rock from the specified work limits of the trench, disposing of same, and backfilling where such is not otherwise provided.

The City defines rock as boulders and pieces of concrete, slag, or masonry exceeding 1/2 cubic yard in volume, or solid ledge rock with a Rock Quality Designation (RQD) of 75 or greater and, that requires drilling and blasting for removal, or wedging or sledging, or barring or breaking up with a power-operated tool.

The City does not define soft or disintegrated rock or slag removable with a hand-pick or power-operated excavator or shovel equipped with bucket mounted rippers, loose, shaken, or previously blasted rock or broken stone in rock fillings or elsewhere, or rock beyond the maximum limits of measurement allowed, that may fall into the excavation as rock.

903.02 Blasting. When and if necessary to blast with explosives for the prosecution of the work, use the highest degree of care and adequate protective measures to not endanger life, completed portions of this contract project, and all other public and private property. Before conducting any blasting operations, furnish the Engineer, in writing, a schedule of intended blasting operations. Provide the Engineer prior written notification of any changes in such schedule.

Use explosives in blasting in accordance with 107.10 and all laws, rules and regulations of the federal, state, local agencies and the insurer governing the keeping, storage, use, manufacturing, sale, handling, transportation, and other disposition of explosives. Conduct operations with every precaution by trained, reliable workers under satisfactory, experienced supervision. Do not initiate a blast until all persons in the vicinity have had notice and reached positions out of danger. The City will make no additional payment for damages resulting from the use of explosives.

Provide public liability and property damage insurance for all blasting operations as specified in this section. Conduct all blasting during the daylight hours only, limited to certain daylight hours if required by the Engineer.

Conduct all firing in accordance with 107.10 and make suitable provisions to prevent the scattering of broken rock, earth, stones or other material during blasting operations.

903.03 Estimated Quantities. Where no data is available as to actual presence of rock, the quantity of rock listed in the estimate is intended only as an allowance for bid purposes if random rock is encountered. Where available data indicates that the Contractor will encounter rock, the quantity listed in the estimate includes the estimated amount based on such data, plus some additional amount as an allowance for possible excess of actual quantity over estimated quantity. The City will estimate the quantity by a straight line profile generated between soil borings where the elevation at the boring is determined by the top of the stratum where the RQD is 75 or greater.

903.04 Method of Measurement. The Engineer will not measure hardpan for payment under this item. The Engineer will calculate the volume of rock in the sewer trench for payment on the basis of the specified trench width and a bottom limiting plane at the level of the subgrade as shown on the applicable standard drawings. The Engineer will determine the upper limit for payment by one of the following methods:

1. **By Stripping.** Remove all earth and other materials capable of removal with an adequately sized excavator equipped with bucket mounted rippers from the rock surface prior to blasting. The Engineer will calculate the volume by measured rock profile elevations.

2. **By the Engineer.** After completing blasting and excavation, the Engineer will determine the profile of the rock that the Contractor could not excavate with bucket mounted rippers and will approximate the top of the stratum where the RQD is 75 or greater.

903.05 Basis of Payment. The City will pay the calculated number of cubic yards of rock excavation measured at the contract unit price per cubic yard.

The City will pay under:

Item	Unit	Description
903	Cubic Yard	Rock Excavation Where the Contractor Can Use Explosives
903	Cubic Yard	Rock Excavation Where the Contractor Cannot Use Explosives

ITEM 904 MISCELLANEOUS CONCRETE STRUCTURES

904.01 Description
904.02 Materials
904.03 Excavation and Backfilling
904.04 Method of Measurement
904.05 Basis of Payment

904.01 Description. This work consists of furnishing all labor, equipment and material including excavation and backfill, form work, concrete and steel reinforcement to construct the miscellaneous concrete structures, not provided for under Item 511 or Item 604, where shown on the plans and as specified. Use procedures, methods, and controls for constructing miscellaneous concrete structures in accordance with Items 508 and 511.

904.02 Materials. Use the following materials:

1. Concrete Class COC 6..... 499, 511
2. Reinforcing steel..... 709
3. Manhole steps..... 711.30 or 711.31
4. Frames, grates, covers 711.12

904.03 Excavation and Backfilling. Perform all excavation for structures shown on the plans in accordance with 901.03 with dimensions that will provide ample room for construction. Remove any obstruction or relocate any utility within 1 foot outside the outer edge of the footing at no additional cost to the City, except as provided in 104.02.B, if applicable. Backfill around the concrete structures in accordance with Item 203 and 901.17.

904.04 Method of Measurement. The Engineer will measure and accept the number of structures of each type completed. The Engineer will measure pipe connecting to the structures, excluding items built under Item 604, built under Item 901 to the inside face of the structure wall.

904.05 Basis of Payment. The City will pay the number of each type of structure completed and accepted at the contract lump sum price for each structure.

The City will pay under:

Item	Unit	Description
904	Lump Sum	Structure at Station _____ + _____

ITEM 905 CONCRETE

905.01 Description
905.02 Materials
905.03 General
905.04 Method of Measurement
905.05 Basis of Payment

905.01 Description. This work consists of furnishing and placing Portland cement concrete consisting of a mixture of Portland cement, fine aggregate, coarse aggregate and water, properly proportioned of the various classes of concrete noted on the plans, in accordance with these specifications and to the lines, grades, and dimensions shown on the plans, or ordered in writing by the Engineer.

905.02 Materials. Use the following materials:

1. Concrete, Class COC 8..... 499
2. Concrete, Class COC 6..... 499

905.03 General. The Engineer may frequently test cylinders as specified in 511.06 throughout the work to determine the quality and strength of the concrete. Furnish all the materials required for testing and cooperate in every way to ensure that concrete of the desired quality and strength is obtained, at no additional cost to the City. Do not place concrete in water, or allow water to rise on or flow over any concrete until it has set at least 24 hours. Immediately before placing concrete, remove all water, softened material and debris from the excavation.

905.04 Method of Measurement. The City will pay for concrete shown on the plans under the respective Item 901 or Item 904 and will not pay separately under this item.

The Engineer will measure and accept concrete under this item within the limits, as ordered in writing by the Engineer, of the Standard Drawings or as specified by the Engineer.

905.05 Basis of Payment. The City will pay for accepted quantities of Portland cement concrete ordered in writing by the Engineer at the contract unit price per cubic yard.

The City will pay under:

Item	Unit	Description
905	Cubic Yard	Concrete, Class COC 8
905	Cubic Yard	Concrete, Class COC 6

ITEM 906 STONE FOUNDATION

906.01 Description
906.02 Materials
906.03 Method of Measurement
906.04 Basis of Payment

906.01 Description. This work shall consists of the excavation for and the placing of specified stone material and the disposal of the surplus excavated material as shown on the plans and where placed as ordered in writing by the Engineer. The purpose of this work is to provide a suitable subgrade for the pipe and appurtenant structures. Compact or consolidate the stone or gravel used as foundation material in such a manner and to provide adequate support for the over-lying structure or material.

The City will not pay separately for placing stone foundation to provide the water free trench as specified by 901.16.

906.02 Materials. Use the following materials:

Stone for foundations .....No. 1, 2 or 467 per Table 703.01-1

906.03 Method of Measurement. The Engineer will measure and accept stone foundation by the number of cubic yards placed, calculated within the authorized excavation limits, as shown on the plans or as ordered in writing by the Engineer.

906.04 Basis of Payment. The City will pay the accepted number of cubic yards of stone foundation measured at the contract unit price per cubic yard. The City will not pay for excavation or material outside the authorized limits.

The City will pay under:

Item	Unit	Description
906	Cubic Yard	Stone Foundation

ITEM 907 SHEETING AND BRACING LEFT IN PLACE

907.01 Description
907.02 Method of Measurement
907.03 Basis of Payment

907.01 Description. This item consists of all sheeting, bracing and other supports left in place where specifically ordered in writing by the Engineer, regardless of the reason or purposes for the installation. Submit shop drawings, accompanied by calculations, stamped by a Professional Engineer registered in the State of Ohio, showing the adequacy of the sheeting, bracing and other supports. Furnish one electronic copy and six (6) paper copies of this information to the Engineer.

907.02 Method of Measurement. The Engineer will measure and accept only sheeting, bracing, and other supports actually left in place by written order of the Engineer for payment. The Engineer will not measure any sheeting, bracing, or other supports cut off, wasted, or extending below the top elevation of the concrete bedding, concrete backing, concrete backfill, or subgrade or left in place without a written order from the Engineer.

907.03 Basis of Payment. The City will pay quantities of sheeting, bracing, and other supports measured and accepted at the contract unit price, per square foot for timber sheeting and bracing and for steel sheeting and bracing left in place.

The City will pay under:

Item	Unit	Description
907	Square Foot	Timber Sheeting and Bracing Left in Place
907	Square Foot	Steel Sheeting and Bracing Left in Place

ITEM 908 TUNNEL

908.01 Description
908.02 Materials
908.03 General
908.04 Construction Layout and Alignment Holes
908.05 Tunnel Shield
908.06 Tunnel Lining
908.07 Excavation
908.08 Soil Stabilization
908.09 Dewatering
908.10 Grouting
908.11 Fill Material

908.12 Method of Measurement
908.13 Basis of Payment

908.01 Description. This work consists of the construction of a tunnel and pipe sewer. The work includes the excavation, removal of water, furnishing and installing a tunnel liner, and the construction of the tunnel end bulkheads as shown on the plans and specified in this section. Provide a tunnel liner of sufficient size to accommodate the placement of the sewer and fill material, grouting, the placement of a paved tunnel liner invert or sewer pipe support structure, and laying the sewer pipe. The Contractor may use Item 909 as a substitute, if conditions warrant and if approved by the Engineer.

908.02 Materials. Use the following materials:

1. Tunnel liner 908.06
2. Cement for grout 701
3. Sand for grout..... 703.03
4. Concrete, Class COC 8..... 499, 905
5. Pipe sewer 901.02
6. Controlled density fill mixes, cementitious material for fill..... 613, 912.02

908.03 General. Ensure tunneling within the right-of-way of private companies and public agencies conforms to the requirements and regulations of the respective companies or agencies. Before proceeding with the tunneling work, prepare and submit to the Engineer for approval, the necessary working schedule, a description of the type of materials planned for use in the work, and the planned methods of construction. Submit shop drawings, accompanied by calculations, and stamped by a Professional Engineer registered in the State of Ohio, showing the adequacy of the liner materials and shield. Furnish one electronic copy and six (6) paper copies of the shop drawings to the Engineer. The Engineer will forward copies to any authority involved for authority approval. The Engineer will return one approved copy to the Contractor. Contractor shall pay any costs that may result due to the authority's requirements, of whatever nature, including furnishing of watchmen and supervision by the authority's forces.

Where work under this item involves tunneling under railroad tracks, all operations of the Contractor or his agents and employees must be subordinate to the free and unobstructed use and conduct of the railroad company's business without delay or danger to life, equipment or property. The Contractor shall save harmless the railroad company against all claims, suits or judgments arising because of or resulting from the operations, actions or omissions of the Contractor or his agents and employees. The Contractor shall obtain all permits necessary for such work. In addition, the Contractor shall obtain Railroad Protective Liability Insurance as required under 103.09.F. The Contractor shall carry on his operations in such a manner that all work shall be performed below track level and without obstructions on the railroad roadbed.

908.04 Construction Layout and Alignment Holes. The City will locate and reference the centerline of the project, unless there is a separate pay item for Item 623. The Contractor shall protect and replace all control points. Use competent personnel and suitable equipment for the layout work required and provide supervision of the work by a Registered Professional Engineer or a Registered Surveyor. Submit field notes of all layout work to the City.

For tunnels greater than 400 feet in length, drill alignment holes, unless otherwise directed by the Engineer. Drill alignment holes at a maximum of 400 feet apart along the centerline. Drill additional alignment holes if the Engineer determines that the tunnel is not on line and grade within the limits specified. Drill the holes to such depth as is necessary for the casing to extend into the tunnel excavation. Provide a casing of adequate size and strength, 6 inch minimum, to line the hole. Set the casing vertically.

Where a hole is located in the existing pavement, cut the pavement before drilling the hole. After the casing is in place, insert a suitable, substantial cover in the casing at street grade, and fill the space outside the casing with concrete.

Following completion of the tunnel liner, the Contractor may use the alignment holes for grouting voids. After completion of the pipe installation and grouting, fill the alignment holes with controlled density fill material in accordance with Item 613.

908.05 Tunnel Shield. The City requires the use of a tunneling shield for all liner plate and railroad installations.

Use a steel shield designed to support the loading from the installation. Provide a hood or an approved grid system to protect the advancing face with sufficient length to install 1 complete ring of liner plates or one set of ribs and lagging within the shield before advancing. Ensure the hood or approved grid system does not exceed the outside dimensions of the tunnel liner plate installation by more than 1 inch at any point on the periphery.

Adequately brace the shield and provide appurtenances for completely bulkheading the face. Submit bracing and bulkhead details with the design information.

908.06 Tunnel Lining. Install the tunnel liner providing strength commensurate with the tunnel diameter and depth of cover and in accordance with the design requirements of the private or public authority involved. Before initiating construction, provide the liner details, reasons for selecting the liner supports and materials, and calculations demonstrating the adequacy of the method of tunnel liner support to the Engineer.

When using ribs and lagging for tunnel lining, use a rib expander to expand the rib outward and upward by a continuous contact between the rib expander and the rib.

Provide tunnel liner plates with a minimum of 12 gage, hot rolled, structural quality carbon steel plates conforming to ASTM A-569. Offset each ring by rotating the starting plate, so that end flanges of the adjacent rings do not fall in line.

908.07 Excavation. Excavate all material of whatever nature encountered, including rock, necessary for the construction of the work. Consider all excavated material as unclassified material. Do not advance excavation beyond the edge of the shield, except in rock.

908.08 Soil Stabilization. The Engineer may direct pressure grouting of the soils or freezing of the soils before jacking, boring, or tunneling to stabilize the soils, control water, prevent loss of material and prevent settlement or displacement of embankment. Use cement or chemical grout or other special injection material selected to accomplish the necessary stabilization.

Submit a plan prepared by a Registered Professional Engineer, or by an experienced and qualified company specializing in this work detailing the materials planned for use in the work and the proposed injection method. Submit to the Engineer for approval before starting work. Include proof of experience and competency with the submission. If Soil Stabilization is required by the changed conditions as described in 104.02, the City will pay for this work in accordance with 104.02.

908.09 Dewatering. When the Contractor is expected to encounter water, provide and maintain pumps of sufficient capacity to handle the flow at the site. Closely observe the dewatering process to detect any settlement or displacement of railroad embankment, tracks, pavement, and other facilities.

908.10 Grouting. Keep grouting as close to the heading as possible, using grout stops behind the liner plates, if necessary. Provide grout holes in the tunnel lining with a spacing not to exceed 4.5 feet measured longitudinally. Vary the location of holes around the periphery of the tunnel lining to suit field conditions, permitting the proper grouting sequence to ensure complete filling of void spaces outside the tunnel lining (recommended initial spacing at 3 feet). Fill all the void space outside the tunnel lining caused by the tunneling with 1:3 (cement:sand) cement grout. Perform grouting if ordered by the Engineer. Do not progress the tunnel more than 6 lineal feet beyond the grouting without prior written approval of the Engineer. Grout all completed sections if work is suspended for more than 24 hours. Start the grouting at the lowest hole in each grout panel and proceed upward simultaneously on alternating sides of the pipe. Install a threaded plug in each grout hole when the grouting is completed at that location. Bulkhead the face of the tunnel by approved methods whenever the job is vacated or if directed by the Engineer.

Use a grouting machine that applies a pressure up to 75 pounds per square inch in excess of any external water pressure. Provide a grouting machine with a gauge that accurately indicates working pressure. Monitor the gauge during grouting operations. Do not exceed the pressure considered safe or that would distort the tunnel lining or that would lift and/or displace the overburden. Use grout pipes with a minimum of 1 ½ inches inside diameter. In freezing temperatures, heat mixing water for grout and provide proper insulation to prevent grout from freezing in grout tubes from point of initial discharge to final position of grout in place.

908.11 Fill Material. After installation of the sewer in the tunnel lining, completely fill the space between the tunnel liner and the sewer with 1:5 (cement:sand) Portland Cement grout, Class COC 8 concrete, or Item 613 Flowable Controlled Density Fill mixes.

908.12 Method of Measurement. The Engineer will measure the length of tunnel and appurtenances by the actual number of linear feet accepted, as measured along the centerline of the sewer, complete in place. When the tunnel shaft is included in the tunnel unit prices, the Engineer will measure from the center of the tunnel shaft.

908.13 Basis of Payment. The City will pay the accepted number of linear feet of tunnel for the pipe sizes specified at the contract unit prices per linear foot complete in place. Include the cost of the tunnel shaft in the unit price bid for the tunnel, unless a separate bid item for Tunnel Shaft (Item 920) is included in the Contract. If the shaft is included with the tunnel unit prices, the City will pay from the center of the shaft to the end of the tunnel. If a separate bid item for Tunnel Shaft (Item 920) is included, the City will pay for the tunnel starting 1.33 feet inside the outside wall of the shaft.

The City will pay for the sewer pipe under Item 901.

The City will pay under:

Item	Unit	Description
908	Linear Foot	Tunnel for ____ Inch Diameter Pipe, Including Shaft
908	Linear Foot	Tunnel for ____ Inch Diameter Pipe, Excluding Shaft

ITEM 909 TUNNEL – JACKED LINER

909.01 Description
909.02 Materials
909.03 General
909.04 Construction Layout and Alignment Holes
909.05 Jacking Shield
909.06 Tunnel Lining
909.07 Excavation
909.08 Soil Stabilization
909.09 Dewatering
909.10 Grouting
909.11 Fill Material
909.12 Method of Measurement
909.13 Basis of Payment

909.01 Description. This work consists of furnishing and installing a tunnel liner of sufficient diameter to permit the installation of the sewer therein and encasing the sewer in the liner. This work includes all excavation, shoring and bracing, jacking pit and appurtenances (except for

separate contract pay item), backstops, jacks, jacking shields, hoods, breasting attachments, grout holes and plugs, grout and other incidentals as needed for the installation. The Contractor may install the liner by jacking and hand mining, by spoil removal with a boring auger, or by tunnel boring machine.

909.02 Materials. Use the following materials:

1. Tunnel liner 909.06
2. Cement for grout 701
3. Sand for grout 703.03
4. Concrete, Class COC 8/Class COC 6 ..... 499, 905
5. Pipe sewer 901.02

909.03 General. Perform work in jacked tunnels in accordance with the requirements of 908.03. Jack in one direction only.

1. **Boring.** This method consists of pushing (jacking) the pipe into the earth with a boring auger rotating within the pipe to remove the spoil.
2. **Jacking.** This method consists of pushing sections (strings) of pipe into position with a tunnel boring machine, or with jacks placed against a backstop and excavation performed by hand within the jacking shield or liner at the head of the pipe.

909.04 Construction Layout and Alignment Holes. Perform work in conformance with 908.04.

909.05 Jacking Shield.

1. **Jacking Shield for Reinforced Concrete Pipe.** Provide a separate jacking shield, a tunnel boring machine or a shield fabricated as a special section of reinforced concrete pipe with steel cutting edge, hood, breasting attachments, and other necessary appurtenances cast into the pipe if required by the Engineer. Design the wall thickness and reinforcing for the jacking stresses. Do not plan for the fabricated shield to remain as a part of the tunnel liner, unless specifically designed for that purpose and the design is approved by the Engineer.
2. **Jacking Shield for Smooth Steel Pipe Liner.** Provide a separate shield, or the leading section of conduit equipped with a securely anchored jacking head to prevent wobble and variation in alignment if required by the Engineer. The Contractor may use a modified section of standard pipe with the necessary breasting attachments and capability to completely bulkhead the face if approved by Engineer.
3. **Boring Head and Auger Assembly.** Submit details showing the equipment and the methods of operation the Contractor plans to use. The Engineer may require devices to prevent the cutting head from leading the pipe. Use a cutting head designed to obstruct the flow of soft or poor soil through the face. Use a cutter head and auger assembly designed to allow the entire removal of the boring equipment from inside the liner. Limit the over cut to the minimum amount required for the installation and conduct operations to prevent unsupported excavation ahead of the liner pipe.

909.06 Tunnel Lining. Provide tunnel lining with strength commensurate with the tunnel diameter, depth of cover, and jacking thrust and with adequate buckling resistance, all in accordance with the design requirements of the authorizing entity. Submit to the Engineer design calculations prepared and stamped by a Professional Engineer registered in the State of Ohio demonstrating the capability of the materials proposed.

1. **Reinforced Concrete Pipe Liner.** Provide reinforced concrete pipe liner with tongue and groove joints conforming to ASTM C-76, Class V Wall C. Provide a pipe design for approval by the Engineer.
2. **Smooth Steel Pipe.** Provide smooth steel pipe having a minimum yield strength of 35,000 psi with a maximum diameter of 72 inches (nominal). Use tunneling procedures described under Item 908 for larger than 72 inch smooth steel pipe sizes. Provide the following minimum wall thicknesses for the nominal sizes shown for railway installations with 5 foot 6 inches of cover (minimum).

Nominal Diameter (inches)	Nominal Thickness (inches)
10 and under	0.188
12 and 14	0.250
16	0.281
18	0.312
20 and 22	0.344
24	0.375
26	0.406
28	0.438
30	0.469
32	0.500
34 and 36	0.532
38	0.562
40	0.594
42	0.625
44 and 46	0.657
48	0.688
50	0.719
52	0.750
54	0.781
56 and 58	0.812
60	0.844
62	0.875
64	0.906
66 and 68	0.938
70	0.969
72	1.000

The Engineer will consider wall thicknesses for other conditions of loading if justified by the submitted engineering calculations.

Fully weld joints between sections of steel pipe around the circumference. Provide any stress transfer across the joint necessary to ensure capability to resist the jacking forces involved.

909.07 Excavation. Excavate all material of whatever nature encountered, including rock, necessary for the construction of the work. The City considers all excavated material as unclassified material. Do not excavate beyond the edge of the hood, shield or liner, except in rock.

909.08 Soil Stabilization. Perform soil stabilization in accordance with the requirements in 908.08.

909.09 Dewatering. Perform dewatering in accordance with the requirements in 908.09.

909.10 Grouting. The Contractor may place grout by grout pipes from the ground surface where conditions permit. On railroad and main highway installations, place the grout from within the jacked liner, or other approved method.

Locate grouting holes for smooth steel liners in accordance with 908.10. For railroads, provide tapped grout holes at least 1 1/2 inches diameter. For reinforced concrete pipe, provide grout holes cast into the liner at manufacture. Space the holes 4 feet longitudinally and approximately 3 feet circumferentially. For other installations, the Engineer will approve the grouting arrangement.

Use grout with a 1:3 (cement:sand) cement grout mixture. Start the grouting immediately after completing the jacking/boring operation. Provide a grouting machine, gauge, pressures, and cold weather instructions in accordance with 908.10.

909.11 Fill Material. Provide fill material in accordance with the requirements in 908.11.

909.12 Method of Measurement. The Engineer will measure and accept the length of jacked liner and appurtenances for payment by the actual number of linear feet, as measured along the centerline of the sewer lines. If the tunnel liner unit price includes the tunnel shaft-jacking pit, the Engineer will measure from the center of the jacking pit to the end of the tunnel liner.

909.13 Basis of Payment. The City will pay the accepted number of linear feet of tunnel-jacked liner of the sizes required at the contract unit prices per linear foot complete in place. The City will pay for the encased pipe under Item 901.

The City will pay under:

Item	Unit	Description
909	Linear Foot	Tunnel - Jacked Liner for ____ Inch Diameter Pipe Including Jacking Pit
909	Linear Foot	Tunnel - Jacked Liner for ____ Inch Diameter Pipe Excluding Jacking Pit

ITEM 910 CONCRETE ENCASEMENT FOR SEWERS

910.01 Description

910.02 Materials
910.03 Excavating and Backfilling
910.04 Pipe
910.05 Method of Measurement
910.06 Basis of Payment

910.01 Description. This work consists of furnishing and installing reinforced or plain concrete encasement of sewer pipes as shown on the plans and as specified in this section.

910.02 Materials. Use the following materials:

1. Concrete, Class COC 8..... 499, 511
2. Reinforcing steel..... 709

910.03 Excavating and Backfilling. Perform excavating and backfilling as specified under 901.03 and 901.17. The City will pay for excavating and backfilling under Item 901.

910.04 Pipe. Encase pipe in accordance with the Standard Drawings and as specified under all the applicable parts of Item 901 pertaining to furnishing and installing pipe. The City will pay for pipe under Item 901. When encasing flexible pipe, extend the concrete encasement from structure to structure along the entire length of the pipe.

910.05 Method of Measurement. The Engineer will measure the length of encasement of sewer by the actual number of linear feet accepted, measured along the centerline of the sewer complete in place.

910.06 Basis of Payment. The City will pay for the accepted number of linear feet of reinforced or non-reinforced encasement work of the sizes specified at the contract unit price per linear foot complete in place.

The City will pay under:

Item	Unit	Description
910	Linear Foot	Plain Concrete Encasement of ___ Inch Diameter Pipe
910	Linear Foot	Reinforced Concrete Encasement of ___ Inch Diameter Pipe

ITEM 911 COMPACTED BACKFILL

911.01 Description
911.02 Materials
911.03 General
911.04 Method of Measurement
911.05 Basis of Payment

911.01 Description. This work consists of compacting native or excavated material as trench backfill where shown on the plans or ordered by the Engineer and as specified in this section.

911.02 Materials. Use suitable material native to the project or a granular material meeting the requirements of 912.02 and as approved by the Engineer.

911.03 General. If excavated material is unsuitable for compacted backfill or if it is impracticable to use the excavated material to meet the requirements of this item, provide suitable backfill material elsewhere and dispose of the unsuitable material at no additional cost to the City.

Ensure backfilling conforms in every respect with the provisions of 901.17 and the compaction requirements of 912.03, as determined by the results of tests ordered by the Engineer. Spread soil, granular material, or other approved material in successive level layers of a depth not more than 8 inches in thickness (loose measurement), unless otherwise specified and/or authorized in writing by the Engineer.

911.04 Method of Measurement. The Engineer will calculate the number of cubic yards of compacted backfill for payment on the following basis:

Volume in cubic yards equals W times L times D divided by 27 where W is the specified trench width in feet, L is the length of trench in feet as specified or ordered compacted and D is the distance in feet from 1) the top of the bedding or encasement on 6 through 27 inch pipe or 2) the top of the outside barrel of the pipe or encasement on 30 inch and larger pipe to a point 1 foot below the existing ground elevation. These definitions for the D measurement may vary as indicated in the plans or as specified or as ordered by the Engineer. The Engineer will measure the length of trench along the centerline of the sewer in place without deduction for manholes or other structures built in the open trench. The City will not pay extra for compacted backfill in the extra excavation widths necessary at manholes and other structures along the centerline of the work. At existing manholes or structures, where the work connects, the Engineer will measure this item from the centerline of the existing manhole or structure. At terminal manholes or structures, constructed as part of the work, the Engineer will measure for this item through the manhole or structure to a point 1 foot beyond the manhole or structure base. Where building manholes or structures over existing sewers, as part of the work, the Engineer will measure compacted backfill along the centerline of the sewer between two points 1 foot beyond and on either side of the manhole or structure base. Where sewer trenches intersect, at different elevations or at a manhole or structure constructed as part of the work, the Engineer will deduct from the above measurement a length equal to the specified width of trench for the lesser diameter pipe for the length of the intersection.

The City will not pay for the following:

1. Substitution of granular or any other material for backfill material.
2. Procurement of suitable backfill material elsewhere.
3. Work necessitated or material placed outside of the payment limits described above, which is necessary to secure the required compaction within the length of trench specified or ordered, due to unauthorized excavation.

911.05 Basis of Payment. The City will pay the computed number of cubic yards of compacted backfill measured at the contract unit price per cubic yard.

The City will pay under:

Item	Unit	Description
911	Cubic Yard	Compacted Backfill

ITEM 912 COMPACTED GRANULAR MATERIAL

912.01 Description
912.02 Materials
912.03 Compaction Requirements
912.04 Method of Measurement
912.05 Basis of Payment

912.01 Description. This work consists of furnishing, placing and compacting granular material for bedding, backfill or other use where shown on the plans, specified or ordered by the Engineer, including the disposal of excess material.

912.02 Materials. Use the following materials:

Unless otherwise shown, specified, or ordered, provide granular material meeting the requirements of 703.11, incorporated in a 6 inch layer.

The Contractor may use controlled density fill mixes as an alternate to compacted granular material, conforming to the requirements of Item 613.

Do not use RPCC as bedding, initial backfill, or final backfill material for any metal sewer pipe installation.

912.03 Compaction Requirements. Apply the following compaction requirements to granular materials and to native backfill materials if such materials require compaction in accordance with Item 911.

Max. Lab. Dry Wt. Lbs./cu. Ft.	Min. Comp. Requirements % Lab. Max.
90-104.9	102%
105-119.9	100%
120 and more	98%

Consider materials having a maximum laboratory dry weight of less than 90 lbs./cu. ft. unsuitable for backfill. Spread soil, granular material, or other approved material in successive level layers of a depth to allow compaction to the specified density and of not more than 8 inches in thickness (loose measurement), unless otherwise specified and/or authorized in writing by the Engineer.

Cooperate to the fullest extent to accommodate compaction tests. The City will not pay for delay or time lost due to verification of compaction required.

912.04 Method of Measurement. The Engineer will calculate the number of cubic yards of compacted granular material on the following basis:

The number of cubic yards is equal to W times L times D divided by 27 where W is the specified trench width in feet, L is the length of trench in feet specified or ordered backfilled with compacted granular material and D is the distance in feet from 1) the top of the bedding or encasement on 6 through 27 inch pipe or 2) the outside top of the barrel of the pipe or encasement on 30 inch and larger pipe to a point 1 foot below the existing ground surface. These definitions for the D measurement may vary as indicated on the plans or as specified or as ordered by the Engineer. The Engineer will measure the length of trench along the centerline of the sewer in place without deduction for manholes or other structures built in the open trench. The City will not pay extra for compacted backfill in the extra excavation widths necessary at manholes and other structures along the centerline of the work. At existing manholes or structures, where the work connects, the Engineer will measure this item from the centerline of the existing manhole or structure. At terminal manholes or structures, constructed as part of the work, the Engineer will measure this item through the manhole or structure to a point 1 foot beyond the manhole or structure base. Where building manholes or structures over existing sewers, as part of the work, the Engineer will measure compacted backfill along the centerline of the sewer between two points 1 foot beyond and on either side of the manhole or structure base. Where sewer trenches intersect, at different elevations or at a manhole or structure constructed as part of the work, the Engineer will deduct from the above measurement a length equal to the specified width of trench for the lesser diameter pipe for the length of the intersection.

The City will not pay for the following:

1. Work necessitated or material placed outside of the payment limits defined above, within the length of trench specified or ordered, due to unauthorized excavation.
2. Compacted granular material for bedding, backing or other use which is paid for under Item 901 as a part of the price per ft. of pipe.

912.05 Basis of Payment. The City will pay the calculated number of cubic yards of granular backfill measured at the contract unit price per cubic yard.

The City will pay under:

Item	Unit	Description
912	Cubic Yard	Compacted Granular Material

ITEM 913 CHANNEL

913.01 Description
913.02 Materials
913.03 Excavation
913.04 Paving
913.05 Sodding
913.06 Method of Measurement
913.07 Basis of Payment

913.01 Description. This work consists of constructing or improving channels including clearing and grubbing, excavation, removal of surplus and unsatisfactory material, compacted backfill, concrete paving, steel reinforcing, special joints, finished grading, sodding, ditch and pipe modifications and connections as specified and as shown on the plans. Work performed under this item shall comply with the City's Stormwater Drainage Manual.

913.02 Materials. Use the following materials:

1. Concrete, Class COC 6..... 499, 511
2. Reinforcing steel..... 709
3. Sodding..... 660

913.03 Excavation. Perform excavation in accordance with the applicable sections of 901.03 and compaction of required backfill in accordance with 203.07.

913.04 Paving. Place plain or reinforced concrete paving to the lines and at the grades shown on the plans.

913.05 Sodding. Perform sodding as shown on the plans conforming to the requirements of Item 660.

913.06 Method of Measurement. The Engineer will measure the length of channel for payment by the actual number of linear feet accepted, as measured along the centerline of the channel. This measurement includes all connections and appurtenances.

913.07 Basis of Payment. The City will pay the accepted number of linear feet of the type of channel shown on the plans at the contract unit price per linear foot.

The City will pay under:

Item	Unit	Description
913	Linear Foot	Channel Construction, Unpaved
913	Linear Foot	Channel Construction, Paved, Plain Concrete
913	Linear Foot	Channel Construction, Paved, Reinforced Concrete
913	Linear Foot	Channel Improvement, Unpaved
913	Linear Foot	Channel Improvement, Paved, Plain Concrete
913	Linear Foot	Channel Improvement, Paved, Reinforced Concrete

ITEM 914 SIX-INCH DIAMETER PIPE RISERS

914.01 Description
914.02 Materials
914.03 General
914.04 Method of Measurement
914.05 Basis of Payment

914.01 Description. This work consists of furnishing and installing 6 inch diameter pipe risers of the kinds specified, shown on the drawings compatible with the type of material as the lateral sewer, or as directed by the Engineer including the necessary excavation and backfill, Class COC 8 concrete foundation, straight and curved pipe, stopper, joints, couplings, cap and marker pole.

914.02 Materials. Use the following materials:

1. Concrete, Class COC 8 499
2. Extra strength vitrified clay pipe 706.08
3. Gaskets for vitrified clay pipe 901.15
4. Poly vinyl chloride (PVC) sewer pipe 720
5. Gaskets for PVC pipe joints 901.15

914.03 General. Perform excavation and backfilling as specified in Item 901.

Install risers, when the depth exceeds 10 feet, from the lateral sewer fitting to a point 9 feet plus or minus 1 foot below existing or proposed surface elevation, whichever is higher.

Install stoppers, plugs or caps, fitted to the type of gaskets used, in the risers when not making immediate connections to services. Provide a waterproof enclosure for the installed piece installed in such a manner that removal of the stoppers later will not damage the gaskets or pipes.

Above each sewer fitting, end of riser or house service extension, set a 4 inch by 4 inch pressure-treated or hardwood pole extending to a point above the partial backfilling. Brace the pole in such a manner as to hold it firmly in position during complete backfilling. After the Engineer has located the poles, cut off the pole to a point slightly below the original ground surface at no additional cost to the City.

Close the upper end of the last section of riser pipe with a plug or cap. Construct the risers in accordance with the Contract Drawings.

914.04 Method of Measurement. The Engineer will measure and accept for payment the number of linear feet of 6 inch diameter pipe risers constructed in place. The Engineer will measure the length of pipe installed from the face of the hub of the Wye fitting or Tee fitting at the sewer to the face of the last hub of the riser where a connection to a service is made or a plug is installed.

914.05 Basis of Payment. The City will pay the number of linear feet of 6 inch diameter pipe risers measured for payment at the contract unit price per linear foot.

The City will pay under:

Item	Unit	Description
914	Linear Foot	6 Inch Diameter Pipe Risers

ITEM 915 WYES, FITTINGS AND CLEAN-OUTS

915.01 Description
915.02 Materials
915.03 General
915.04 Method of Measurement
915.05 Basis of Payment

915.01 Description. This work consists of furnishing and installing plugged Wye fittings in the sewer where shown on the plans or directed by the Engineer and as specified in this section. The Wye fitting shall be of the type specified or shown on the plans and shall be of the same type of material as the lateral sewer, or as directed by the Engineer. Construct clean-outs in accordance with the standard drawing and of the same type of material as the lateral sewer, or as directed by the Engineer. Provide clean-out spacing no greater than 100 feet.

Install risers in accordance with Item 914, when the depth exceeds 10 feet from the lateral sewer fitting to a point 9 feet plus or minus 1 foot from existing or proposed surface elevation, whichever is higher.

915.02 Materials. Furnish and install all materials in accordance with the plans or as directed by the Engineer conforming in all respects to the applicable provisions of Item 901 and Item 914.

915.03 General. Perform the insertion of fitting connectors into all pipe sewers in a manner satisfactory to the Engineer.

When installing a fitting connection as a part of the construction of a new sewer line, construct the connection by installing a prefabricated solid Wye fitting pipe section. Construct the Wye section of the same material as the main line sewer. For flexible sewers 18 inches and larger, make the connection by installing a cored service connection fitting or an approved equal in accordance with the manufacturer's direction.

Securely seal the end of each fitting with a stopper or cap, to form a water tight closure and so that removal of the stopper or cap later will not damage the gaskets.

Above each sewer fitting, set a 4 in by 4 inch pressure-treated or hardwood pole extending to a point above the partial backfilling. Brace the pole in such a manner as to hold it firmly in position during complete backfilling. After the Engineer has located the poles, cut off the pole to a point slightly below the original ground surface at no additional cost to the City.

The City will accept the following connections for use on existing city sewer main lines:

Clay Main Line.

1. Insert clay wye into main by using a preformed shielded rubber coupling rings in accordance with the current City of Columbus Approved Producers/Products List, clay to clay coupling.
2. Insert a clay wye/saddle into the main and concrete encase the saddle connection.

3. Insert a PVC wye connection into the main using a preformed shielded rubber coupling rings in accordance with the current City of Columbus Approved Producers/Products List to PVC couplings.
4. Core drill and install a cored service connection fitting in accordance with the current City of Columbus Approved Producers/Products List.

Concrete Main (15 inch and under).

1. Insert a clay wye into the main by using a preformed shielded rubber coupling rings in accordance with the current City of Columbus Approved Producers/Products List concrete to clay coupling.
2. Insert a PVC wye into the main by using a preformed shielded rubber coupling rings in accordance with the current City of Columbus Approved Producers/Products List concrete to PVC coupling.
3. Core drill and install a cored service connection fitting in accordance with the current City of Columbus Approved Producers/Products List.

Concrete Main (18 inch and larger).

1. When making sewer taps into an existing concrete pipe of 18 inches or larger in diameter, core drill the concrete main line sewer and install a cored pipe to pipe connector in accordance with the current City of Columbus Approved Producers/Products List. Install the pipe to pipe connector in accordance with the manufacturer's directions. Complete the connection in accordance with the standard drawings.
2. Core drill and install a cored service connection fitting in accordance with the current City of Columbus Approved Producers/Products List.

PVC Main.

1. When making sewer taps into an existing PVC pipe sewer, install a prefabricated solid PVC Wye fitting pipe section with repair couplings as stated in 720.08 and 720.09.
2. Core drill and install a cored service connection fitting in accordance with the current City of Columbus Approved Producers/Products List.

HDPP Main.

1. When making sewer taps into an existing HDPP pipe sewer, install a prefabricated solid HDPP Wye fitting pipe section with repair couplings as stated in 720.13 and 720.14.
2. Core drill and install a cored service connection fitting in accordance with the current City of Columbus Approved Producers/Products List.

GFRP Main.

1. When making sewer taps into an existing GFRP pipe sewer, install a prefabricated solid GFRP Wye fitting pipe section with repair couplings as stated in 720.15.
2. Core drill and install a cored service connection fitting in accordance with the current City of Columbus Approved Producers/Products List.

When making sewer taps into an existing sewer not covered in the above requirements, make the tap in a manner approved and directed by the Engineer.

915.04 Method of Measurement. The Engineer will measure the number of Wye fittings or clean-outs of each kind installed and accepted.

915.05 Basis of Payment. The City will pay the number of each kind of fitting accepted at the contract unit price for each.

The City will pay under:

Item	Unit	Description
915	Each	____ Inch x 6 Inches Diameter Wye Fitting
915	Each	____ Inch x 6 Inches Diameter Cored Service Connection Fitting
915	Each	____ Inch x 6 Inches Diameter Cored Pipe to Pipe Connector
915	Each	Clean-out

ITEM 918 SANITARY HOUSE CONNECTION SERVICE

918.01 Description
918.02 Materials
918.03 Excavation
918.04 Bedding

918.05 Laying Pipe
918.06 Pipe Joints
918.07 Backfilling
918.08 Surface Soil and Restoration of Surfaces
918.09 Service Connections Abandoned
918.10 Method of Measurement
918.11 Basis of Payment

918.01 Description. This work consists of the construction of the sanitary house connection service from the Wye fitting on the main line lateral sanitary sewer to the building drain adapter complete in place. This work includes; excavating for the pipe and the bedding for same, including clearing and grubbing, fill or embankment, and the removal of all materials necessary for placing the pipe, except removals listed separately; furnishing and placing the bedding, concrete backing or encasement, and granular or concrete backfill as required; constructing and subsequently removing all necessary cofferdams, cribs and sheeting; removing water; installing all pipe joints; furnishing and installing all necessary pipe of the types specified or shown on the plans; joining to existing and proposed sewers and plumbing appurtenances as required; furnishing and placing of Y-Poles; restoring disturbed facilities and surfaces; maintaining traffic, drainage, and existing structures; and servicing abandoned connections, all as shown on the drawings and as specified.

918.02 Materials. Provide pipe of the size and type specified in the proposal and shown on the plans and meeting the requirements of the relevant specifications listed in this section. If the kind of pipe is not specifically itemized in the proposal or shown on the plans, use any of the following types of pipe.

Connect sanitary house connection services requiring installation from an existing main line lateral sewer to the existing sewer or appurtenance with the same material fitting or with a flexible adapter approved by the Engineer. Ensure the connection produces as tight a joint between the existing and proposed work as that specified for the sanitary house connection service pipe joint.

Use the following specific materials:

1. Stone or gravel bedding - No. 57 or No. 8..... 703
   or compacted granular material 912.02
2. Concrete for backing and backfill - Class COC 8
   ..... 499, 905
3. Extra strength vitrified clay pipe 706.08
5. Poly vinyl chloride (PVC) sewer pipe 720
6. Ductile iron pipe..... 801.03

918.03 Excavation. Perform excavation work in accordance with Section 901.03.

918.04 Bedding. Provide pipe with a bed of granular material extending from a point 4 inches below the bottom of the pipe to 12 inches above the outside top of the pipe as shown on the Standard Drawing.

Place a cut off trench dam of native clay or impervious soil across and along the trench upstream from the main line sewer connection to retard and resist the movement of groundwater through the trench granular bedding or backfill material in accordance with the Standard Drawing. Compact the trench dams to 6 feet in length, as measured along the service centerline and constructed against the undisturbed trench sides from the subgrade or bottom of the Stone Foundation, whichever is lower, to a limit of 36 inches over the top of the pipe.

918.05 Laying Pipe. Lay pipe in accordance with 901.12. Do not horizontally bend flexible conduits. Do not use horizontal or vertical 90 degree fittings. Use elbows to change direction having at least 1 foot of nipple exposed between fittings.

Plug the end of the sanitary house connection service, installed for future use, with an approved stopper to prevent ground water infiltration.

At the end of the service, set a Y-Pole made of timber not less than 4 inch by 4 inch pressure-treated or hardwood in section with the timber in good condition, straight, sound, and free from large or loose knots. Extend the Y-Pole to a point above the backfill. After the Engineer has located the Y-Poles, cut off the Y-Pole to a point slightly below the original ground surface. Brace the Y-Pole to hold it firmly in position during backfilling. If the Y-Pole gets pulled out or bent over, dig down to its end and replace or straighten the Y-Pole. Place the Y-Pole adjacent to the end of the service, but not on it.

Use sanitary house connections crossing watercourses with five mil thick polyethylene-wrapped ductile iron pipe unless otherwise approved by the Engineer. Extend the pipe 10 feet beyond both banks of the watercourse.

918.06 Pipe Joints. Provide joints for sanitary house connection service lines in accordance with the following:

Material	Joint Specifications
1. Vitrified clay pipe	901.15
3. Ductile iron pipe	901.15
4. PVC plastic pipe	901.15

918.07 Backfilling. Perform backfilling work in accordance with 901.17.

918.08 Surface Soil and Restoration of Surfaces. Perform surface soil and restoration of surfaces work in accordance with 901.18.

918.09 Service Connections Abandoned. If abandoning a sanitary house connection service, cut, cap, or plug at one of the following locations:

1. At the R/W line.

2. Inside the existing sewer easement.

Perform service connection abandonment work at locations as shown on the plan or otherwise as directed by the Engineer.

918.10 Method of Measurement. The Engineer will measure the length of sanitary house connection service on the centerline of the pipe as constructed from the Wye fitting to the end of the sanitary house connection service. This measurement includes all fittings except Wyes.

918.11 Basis of Payment. The City will pay accepted quantities of sanitary house connection service, including furnishing and placing the Y-Pole, at the contract unit prices per linear foot, complete in place.

The City will pay under:

Item	Unit	Description
918	Linear Foot	___ Inch Diameter Pipe, Sanitary House Connection Service
918	Each	Service Connections Abandoned

ITEM 919 WATERCOURSE EROSION PROTECTION

919.01 Description
919.02 Materials
919.03 Excavation and Backfill
919.04 Protection Material
919.05 Method of Measurement
919.06 Basis of Payment

919.01 Description. This work consists of compacting backfill and placing the protection material on the banks and bottom of swales, ditches, channels or streams where shown on the plans, or as ordered by the Engineer, over the full width of the excavated trench to undisturbed earth. Work performed under this item shall comply with the City's Stormwater Drainage Manual.

919.02 Materials. Use the following materials:

1. Dumped Rock Fill, Type B..... 601.08

919.03 Excavation and Backfill. Perform excavation as specified under 901.03 and place backfill meeting the requirements of Item 911. The City will pay for excavation and backfill under Item 901.

919.04 Protection Material. Distribute the rock to a mat thickness of 18 inches. Exercise reasonable care in placing the protection to ensure that the finished surface of the protected trench conforms to the existing bank and bottom contours.

919.05 Method of Measurement. The Engineer will measure the number of square yards of watercourse erosion protection calculated on the following basis.

Square yards equals W times L divided by 9: Where W is the surface width of the rock mat and L is the surface length of the rock mat as measured along the slope of the mat parallel to the centerline of the sewer, both width and length in feet, complete in place.

919.06 Basis of Payment. The City will pay accepted quantities of the following at the contract price:

Item	Unit	Description
919	Square Yard	Watercourse Erosion Protection

ITEM 920 TUNNEL SHAFT/JACKING PIT

920.01 Description
920.02 Materials
920.03 General
920.04 Excavation
920.05 Backfill
920.06 Method of Measurement
920.07 Basis of Payment

920.01 Description. This work consists of the excavation, removal of water, shaft supports, backstops, guides where necessary, and backfill of the shaft or pit at the locations shown on the plans and as specified in this section.

920.02 Materials. Use such materials as required for the method of construction operations and to maintain the vertical face of the shaft excavation. Such materials shall ensure the protection of the work and safety of the personnel.

920.03 General. Submit to the Engineer, prior to the start of operations, the plan of operation and construction schedule, a description of the type of materials the Contractor plans to use, and the materials handling equipment. Indicate the location of the tunnel shaft or jacking pit for the tunnel and pipe sewer size specified on the plans and in accordance with contract documents. Submit shop drawings, accompanied by calculations, and stamped by a Professional Engineer registered in the State of Ohio. Provide one electronic copy and six (6) paper copies of this information to

the Engineer. The Engineer will forward copies to any authority involved for approval. The Engineer will return one copy to the Contractor. Pay any cost that may result due to the authority's requirements, of whatever nature, including furnishing watchman and supervision by its forces, at no additional cost to the City.

Approval of the operation plan and construction schedule by the Engineer shall not relieve the Contractor from its obligations to ensure the safe conduct and quality of the work specified.

920.04 Excavation. Excavate all material of whatever nature encountered, including rock, necessary for the construction of the work to dimensions providing ample room for construction. Remove any obstruction or relocate any utility within 1 foot outside the outer edge of the tunnel shaft at no additional cost to the City, except as provided in 104.02.B, if applicable. Consider all excavated material as unclassified material.

920.05 Backfilling. Perform backfilling work in accordance with 901.17.

920.06 Method of Measurement. The Engineer will measure the number of tunnel shafts or jacking pits at the locations specified by the actual number of each accepted.

920.07 Basis of Payment. The City will pay for tunnel shafts or jacking pits accepted at the contract price for the following:

Item	Unit	Description
920	Lump Sum	Tunnel Shaft at Station ____
920	Lump Sum	Jacking Pit at Station _____

1000 ELECTRICAL

ITEM 1001 STREET LIGHTING

1001.01 Description
1001.02 Materials
1001.03 General
1001.04 Working Drawings
1001.05 Light Poles
1001.06 Foundations
1001.07 Luminaires
1001.08 Ground Rods
1001.09 Pull Boxes
1001.10 Trench
1001.11 Conduit
1001.12 Cable
1001.13 Cable-in-Duct Trenchless Installation
1001.14 Connections
1001.15 Power Service and Control Site
1001.16 Conductor Safety Policy
1001.17 Guidelines
1001.18 Electrical Tests
1001.19 Methods of Measurement
1001.20 Basis of Payment

1001.01 Description. This work consists of furnishing and installing electrical materials and equipment complete and ready for service, in reasonably close conformity with locations, dimensions, and grades shown on the plans or as directed by the Engineer. This work also includes necessary excavation and backfill, and disposal of discarded materials, and restoration of disturbed facilities and surfaces.

The Street Lighting Material and Installation Specifications (MIS) of the City of Columbus, Division of Power, provide the streetlight standards and requirements for the City of Columbus. The MIS include materials used in street lighting systems, installation requirements, method of measurement and basis of payment. Drawings associated with each type of streetlight, equipment and wiring are included in the MIS.

The MIS are supplemental to these specifications and are subject to change by the Division of Power. Prior to bidding the work based on these MIS, contact the Division of Power to verify use of the current specifications. The Division of Power can provide the most current copy of the MIS.

1001.02 Materials. Provide new first quality material complying with the Underwriters Laboratories requirements, the National Electrical Safety Code, and local codes. Do not use material containing polychlorinated biphenyls. Provide electrical parts, wire, switches, and other elements of the installations with ample capacity to carry the required amperage without creating excessive heat or causing an excessive drop of potential.

Except as otherwise provided herein, place a name plate or other type of indelible marking or brand on each individual item of equipment identifying the type, catalog number, and manufacturer.

Refer to the City's most current MIS for specific materials and miscellaneous items.

1001.03 General. In general, refer to ANNEX "C" of the *Illuminating Engineering Society Recommended Practices for Roadway Lighting RP-8* (latest version) for definitions of street lighting terms.

Provide each system in such a manner as to conform to the voltage, amperage, frequency, and type specified. Provide and install all incidentals necessary to provide a complete and practical working unit or system.

Provide installations in accordance with the IEEE National Electrical Safety Code and conform to local laws and codes governing such work.

Obtain and pay for all permits required, and submit a copy to the City upon request.

In order to provide all necessary requirements for the proposed lighting system, cooperate with the agency supplying electrical service also hereinafter referred to as the supplying agency.

1001.04 Working Drawings. Submit an electronic copy of shop drawings, catalog cuts, specifications, photometric data, brochures, data sheets and wiring diagrams of apparatus and equipment to be furnished, as required for approval by the Engineer. Provide documents that show clearly the design, quality, dimensions, and other such information as necessary for a proper evaluation of the items submitted. Ensure that submitted documents identify the specific project number and year with the bid item reference number, and MIS number to which the apparatus or equipment applies. For sheets listing more than one catalog number or type, each item intended to be furnished shall be clearly indicated. Indicate that submitted working drawings comply with applicable specifications.

Do not install any of the items before receiving written approval from the Engineer. After approval, the City will consider the working drawings as supplemental to, but not a substitute for, the original plans. Approval of working drawings does not relieve the Contractor of responsibility for omissions, erroneous or inconsistent dimensions and notations, other errors, or the proper functioning of the completed installation.

1001.05 Light Poles. Set light poles, conforming to approved shop drawings, in the ground, upon the completed concrete foundations or as otherwise specified in the Contract Documents. Plumb the light poles. After installation, adequately ground each light pole as per the MIS and fasten handhole covers or transformer base doors in place.

Compact backfill for poles set in ground using Item 304 in thin layers as directed by the Engineer and as indicated in the MIS.

After installation, inspect painted poles for defects in the painted surfaces. Give minor scratches two coats of matching paint. Allow the first coat to adequately dry before applying the second coat.

The Engineer will not accept poles having major scratches or defects.

1001.06 Foundation. Excavation for foundations shall be completed, as nearly as practicable, to the dimensions shown in the MIS for the foundations. Use cast-in-place Class COC 6 concrete, and construct foundations in accordance with Item 511. The City will not require forms for portions of foundations extending more than 6 inches below the ground line, unless the soil does not have sufficient stability to stay in place during the placing of the concrete. For a foundation excavation showing an unstable condition at the bottom of the excavation, as determined by the Engineer, deepen or enlarge the foundation, as directed by the Engineer. The City will pay for additional quantities of excavation and foundation concrete required by the Engineer for this purpose as provided by Change Order. If a cave-in should occur during excavation, the Contractor may continue excavating using casing, sleeving, or other methods, with the approval of the Engineer.

Place reinforcing steel as specified in accordance with Item 509. Install anchor bolts for light poles in the foundations in accordance with approved shop drawings and anchor bolt setting templates. Finish the tops of foundations smooth and level.

Anchor bolts for light poles with a luminaire mounting arm shall be positioned so that the mounting arm of the pole is perpendicular to the longitudinal centerline of the roadway at that location, unless otherwise specified in the Contract Documents.

For Post Top light poles, the anchor bolts shall be installed in such a manner that the access hand hole of the pole is parallel to the back of curb or roadway when installed.

After form removal, backfill excavated spaces around the foundations with suitable materials placed and tamped in thin layers as directed by the Engineer.

1001.07 Luminaires. Adjust street light luminaires vertically and horizontally to provide the required mounting height and the specified alignment with the roadway. At pole locations where the profile grade exceeds 4 percent, position the vertical axis of the luminaires perpendicular to the longitudinal centerline of the roadway at that location.

1001.08 Ground Rods. Provide ground rod units consisting of the specified type and size installed as per the MIS. Provide additional ground rods as required per the ground testing procedures in 1001.18 (1).

1001.09 Pull Boxes. Provide the types and sizes of pull boxes and covers as specified in the MIS, and locate where designated on the plans. Excavate as nearly as practicable to the outside dimensions of the pull box. Below the pull box, place a 6 inch deep gravel base matching the width and length of the pull box. After setting boxes to proper grades, backfill excavated spaces around the boxes with soil and thoroughly tamp in layers not exceeding 4 inches in thickness, loose depth, to the density required in 203.07.

1001.10 Trench. Do not deviate more than 6 inches from the lines designated for trenches located adjacent to and parallel with curbs or pavements. Place trench backfill in layers not to exceed 4 inches in thickness and compacted with mechanical tampers or other approved compaction equipment as directed. Use backfill material consisting of suitable soil or specified granular materials. Ensure that the material around and in the first 4 inches above the top of the conduit not encased in concrete does not contain pieces larger than 1/2 inch . Use backfill material for trenches in areas of pavement and stabilized aggregate shoulders in accordance with Item 304. Excavate trenches at least 2 feet deep and not more than 12 inches wide.

1001.11 Conduit. Install conduit of the type and size shown on the plans at locations designated by the plans or as directed by the Engineer.

For underground conduits encased in concrete, provide Class COC 6 concrete encasement with a minimum 3 inches of cover on all sides. With multiple conduits, use spacers as shown on the plans or the MIS.

Install each conduit with a minimum amount of bending and ensure that the total bending between adjacent access points (junction boxes, pull boxes, light poles, control equipment enclosures, etc.) does not exceed 270 degrees. Provide a minimum radius of any field bend of not less than 12 times the internal diameter of the conduit. Make field bends in conduit without injuring the protective coating and without reducing the internal diameter at the bend.

Galvanize all rigid ferrous metal conduit, fittings, and appurtenances.

Check each conduit run by rodding or by pushing a mandrel through the conduit run. Remove any obstructions found in the conduit.

Close the ends of all conduit not having circuit wire or cable pulled into it during construction with capped bushings or otherwise seal in an approved manner to completely keep all moisture and foreign matter out of the conduit. Seal terminal points of all conduits containing wire or cable by the application of heat shrinkable tubing or pre-molded boots. Equivalent temporary sealing approved by the Engineer shall be provided immediately after placement of conduit where conductors or cable are not installed promptly in the conduit.

Provide locknuts to fasten the conduit to the junction box where conduit enters a junction box through a slip hole.

1001.12 Cable. Install copper wire cables of the types and sizes required as designated in the plans, and in accordance with the MIS. Support cable installed in light poles with cable grips attached to J hooks at the top interior of the poles. Do not allow the cable to drag against the openings for the bracket arm.

For the purpose of termination or connection to another cable, identify all cables, except structure grounding system cables. Do not splice cable between terminations.

1001.13 Cable-in-Duct Trenchless Installation. Use a guided directional drilling device for trenchless installations.

Install the cable-in-duct in a straight line at a minimum depth of 30 inches.

Install cable-in-duct in sufficient length to allow for splicing loops at light pole foundations, pull boxes, and other locations indicated by the Engineer.

Place the cable-in-duct, complete with splicing loops, prior to installing pull boxes and pouring concrete foundations, unless otherwise directed by the Engineer.

Do not install cable-in-duct when the temperature of the duct falls below 32°F, except with permission of the Engineer.

Completely seal terminal points and splice locations of duct-cable by the application of heat shrinkable tubing or pre-molded boots. Seal promptly upon completion of installation.

1001.14 Connections. Make cable connections in the hand holes or transformer bases of all light poles, and above pavement elevation, using the specified preassembled cable connector kits. Provide quick disconnect connector kits as per the MIS, for use inside of pole hand holes and transformer bases.

Use a permanent water resistant cable splicing kit for cable connections below ground line in accessible enclosures, such as pull boxes. Use kits that provide splices in compliance with ANSI C 119.1 when applied in accordance with the manufacturer's instructions.

Adequately protect all cable connector kits and exposed cable ends with heat shrinkable caps, taping, or other approved means until completion of cable connections.

1001.15 Power Service and Control Site. Provide and install all equipment necessary to provide complete electrical service to the street lighting and/or other electrical facilities. After completing the system and making ready for service, notify the City or other supplying agency for connections to establish electrical service. Provide the following equipment including but not necessarily limited to, the following items: wood poles, hardware for dead-ending an overhead line, lightning arrestor, weatherhead, conduit riser, meter base, fused main disconnect switch transformer, magnetically held lighting contacts, HOA switch for control of contacts, photoelectric cell, over-current protection devices for each individual branch circuit fed by the control center, enclosures, conduits, fittings, cables, and connectors.

Unless otherwise directed by the Engineer, install the components of the lighting control center in the enclosure with the fused disconnect switch.

Do not fuse branch circuit neutrals. For grounded service, solidly connect and ground branch circuit neutrals. For both a 2 wire grounded and bonded system, and 3 wire grounded street lighting installation, wire as per the MIS.

At the time of installation, face the photoelectric cell due north, unless other orientation is required. Do not rotate the sensor element more than 45 degrees east or west of due north, tilt off of horizontal, or shield with auxiliary devices without prior approval by the Engineer.

Connect all metal equipment housings and conduits to a ground rod installed in accordance with 1001.08. Connect lightning arrestors on incoming service to equipment ground wire only when using grounded neutral service with no required transformation. Otherwise, separately ground these lightning arrestors to a butt ground or to an additional ground rod installed in accordance with 1001.08, and located a minimum of 1 foot from the base of the pole or pad and all other ground rods. Protect grounding cables installed on poles with wood ground wire moldings.

Do not fuse service neutrals. Do not switch grounded service neutrals. Connect grounded service neutrals to a neutral bar in the disconnect enclosure with a screw type pressure connector.

1001.16 Conductor Safety Policy. When the contract involves work on or near the City's electrical facilities, notify the Division of Power Dispatch Center at (614) 645-7627 and fully comply with the Division's **"CONDUCTOR SAFETY POLICY"**. Obtain copies of this policy from the Division of Power.

Follow the most current safety requirements listed in the MIS. The relevant safety-related MIS items include, but are not limited to, MIS-95.

1001.17 Guidelines. Use the following guidelines on each street lighting project:

1. Acceptance and Inspection Guidelines. The City will inspect all street lighting systems that the City of Columbus, Division of Power will maintain, including work in progress to ensure that design and installation of facilities and materials comply with the Division of Power's current MIS. The City will inspect per 109.11 and MIS-177.

2. Guidelines for Signage. Provide project signs as detailed in MIS-180 for all projects that require signage.

1001.18 Electrical Tests. For specified electrical tests, provide all personnel and equipment required to successfully perform the following tests, and submit to the Engineer three certified copies of complete test records on test reporting forms.

Include all costs of labor, materials, equipment, electrical energy and incidentals required for performing the following electrical tests in the contract unit prices for the respective items tested.

Submit to the Engineer the types, styles, or catalog numbers of all testing equipment planned for such tests. Include a written certification stating the date of the testing equipment's last calibration by a testing agency with qualifications acceptable to the Engineer. Use testing equipment calibrated no more than 6 months prior to performing the required electrical tests.

1. Ground Test. Measure each ground rod and ground grid for earth resistance immediately after installation and before attaching the ground wire. Do not exceed an earth resistance measurement of 25 ohms.

If the earth resistance measurement exceeds 25 ohms, install additional ground rods until achieving measurements less than 25 ohms. If the earth resistance exceeds 25 ohms, permanently connect the first two rods using the same type of cable used for the grounding conductor and continue to add rods one at a time as directed by the Engineer.

Where rock prevents driving of ground rods, develop an earth connection by constructing a grid from the partially driven rods supplemented by buried bare cable as directed by the Engineer.

2. Cable Continuity Test. Prior to cable insulation tests, perform a continuity test with a volt-ohmmeter or other approved instrument. Conduct continuity tests with electrical loads, power sources, and grounds, including earth grounds, disconnected.

Measure each conductor against every other conductor and ground, including earth ground, to ensure that no short circuits, cross circuits, or other improper connections exist. Ensure that no voltage exists between any conductor and another conductor, including ground. One at a time, temporarily short each circuit branch at its termination and measure for continuity to ensure no open circuits exist, the circuit branch complies with the plan, no high resistance connections exist, and proper identification of each circuit.

3. Cable Insulation Test. Measure the insulation resistance for each insulated cable of the circuit, including duct-cable. Perform the test on each cable of each circuit with all ballasts disconnected and all connections to earth grounds, including ground rods and grounding connections to light poles, disconnected. Express the units of measure for reporting in megohms. Ensure the cable insulation resistance exceeds 10 megohms.

4. Voltage Regulation and Current Balance Test. Energize the circuit and the Engineer will make a visual check to confirm operation of all lights. After a ten minute warm-up period, measure and record the following data on the test reporting form:

A. Operating current of each circuit;

B. Circuit voltage at controller;

C. Circuit voltage at the end light of each circuit as designated by the Engineer.

1001.19 Methods of Measurement. Method of Measurement shall be as defined in the applicable MIS.

When the Contract stipulates that payment will be made for specific complete electrical equipment installation on a lump sum basis, the pay item stipulated will include all electrical materials, equipment and incidentals, including specified tests required at the locations and within the limits specified on the plans, complete in place.

1001.20 Basis of Payment. The City will pay the contract price as specified in the applicable MIS.

ITEM 1002 POWER TRANSMISSION AND DISTRIBUTION STANDARDS

FORMER ITEMS 1002 AND 1003 HAVE BEEN DELETED
THIS ITEM REPLACES FORMER ITEM 1004

1002.01 Description
1002.02 Materials
1002.03 General
1002.04 Document Submittals
1002.05 Method of Measurement
1002.06 Basis of Payment

1002.01 Description. This work consists of furnishing and installing transmission and/or distribution materials and equipment complete and ready for service, in reasonably close conformity with locations, dimensions, and grades shown on the plans or as directed by the Engineer. This work also includes necessary excavation and backfill, disposal of discarded materials, and restoration of disturbed facilities and surfaces.

The Transmission and Distribution Material and Installation Specifications (TDMIS) of the City of Columbus, Division of Power, provide the transmission and distribution standards and requirements for the City of Columbus. The TDMIS include materials used in transmission and distribution systems, installation requirements, method of measurement and basis of payment. Drawings associated with the transmission and distribution materials, equipment and wiring are included in the TDMIS.

The TDMIS are supplemental to these specifications and are subject to change by the Division of Power. Prior to bidding the work based on these TDMIS, contact the Division of Power to verify use of the current specifications. The Division of Power can provide the most current copy of the TDMIS.

1002.02 Materials. Provide new material complying with the Underwriters Laboratories requirements when applicable, National Electrical Safety Code, and local codes. Provide all materials, poles, insulators, conductors, switches, lightning arresters, etc. for the installation with ample capacity and strength to carry the required amperage and weight for the intended use.

Except as otherwise provided herein, place a name plate or other type of indelible marking or brand on each individual item of equipment identifying it as to type, catalog number, and manufacturer.

Refer to the City's most current TDMIS for specific materials and miscellaneous items.

1002.03 General. Provide the transmission and/or distribution system conforming to the utility's voltage and current requirements as specified. Provide and install poles, equipment, hardware, conductors and all incidentals necessary to provide a complete and practical working unit or system.

Install in accordance with the National Electrical Safety Code, and all state and local codes governing such work. When requirements conflict, use the more stringent code for the work. These codes specify the minimum requirements for all transmission and/or distribution construction work.

Obtain and pay for all construction permits required, and forward a copy to the City upon request.

1002.04 Document Submittals. Provide the Engineer with an electronic copy of all shop drawings, catalog cuts, brochures, data sheets, design calculations, and operation and maintenance manuals of equipment to be furnished. Clearly show on the submitted documents the design, quality, dimensions, and other such information necessary for a proper evaluation of the items submitted. Clearly identify on all submitted documents the specific project number, name, and year with the bid item reference number and TDMIS number to which the apparatus or equipment applies. On catalog cuts if more than one catalog number or type is listed on a sheet, each item intended to be furnished shall be clearly indicated. Indicate specific compliance with applicable specifications on the working drawings submittals.

Provide to the City four paper copies of complete Operation and Maintenance manuals for all electrical equipment requiring electrical or mechanical adjustments. Also, provide and electronic copy of the manual. Manuals shall include the following: common operating problems and remedies (trouble shooting guide); care and preventive maintenance procedures and schedules; spare parts list with recommended spares; descriptive bulletins and detailed drawings; approved shop drawings; and operating instructions.

Submit one hard copy and an electronic copy of corrected as built project drawings within four weeks after completion of project. The City will not make a final payment until the Contractor submits and the Engineer approves the as built drawings and Operation and Maintenance Manuals. Ensure that the as built drawings provide an accurate representation of actual field conditions and installations.

Do not install any of the items before receiving written approval from the Engineer. After approval, the City will consider the working drawings as supplemental to, but not a substitute for, the original plans. Approval of Working Drawings does not relieve the Contractor of the responsibility for omissions, erroneous or inconsistent dimensions and notations, other errors or the proper functioning of the completed installation.

1002.05 Method of Measurement. Measurement will be made for specific items, furnished and in place, complete and accepted, as specified in the applicable TDMIS.

1002.06 Basis of Payment. The City will pay the contract price as specified in the applicable TDMIS.