

SECTION SS-14A

SHOTCRETE CONTINUOUS LINING

PART 1 GENERAL

1.01 SUMMARY**A. Continuous Lining**

1. Where noted on the plans as Continuous Lining, the Contractor shall provide all labor, materials, and equipment necessary to install a continuous and full perimeter cementitious shotcrete sewer lining in accordance with the plans and as specified herein.
2. Dry process cementitious lining shall be utilized where Continuous Lining is specified.

1.02 REFERENCES**A. References Standards: Comply with applicable provisions and recommendations of the following, except as otherwise shown or specified:**

1. American Concrete Institute (ACI) 301, "Specifications for Structural Concrete or Buildings."
2. ACI 304R-00, "Guide for Measuring, Mixing, Transporting, and Placing Concrete".
3. ACI 305R-10, "Guide to Hot Weather Concreting".
4. ACI 306R-10, "Guide to Cold Weather Concreting".
5. ACI 506.IR-84 "State of the Art Report on Fiber Reinforced Shotcrete."
6. ACI 506.R-05 "Guide to Shotcrete."
7. ACI 506.1R-08 "Guide to Fiber Reinforced Shotcrete."
8. ACI 506.2 "Specifications for Materials, Proportioning, and Application of Shotcrete."
9. ACI 506.2-95 "Specifications for Shotcrete."

10. ACI 506.3R-91 "Guide to Certification of Shotcrete Nozzlemen."
11. ACI CP-60 "Craftsman Workbook for ACI Certification of Shotcrete Nozzleman."
12. ASTM C 39, "Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens."
13. ASTM C 1140, "Standard Practice for Preparing and Testing Specimens from Shotcrete Test Panels."
14. ASTM C 1385, "Standard Practice for Sampling Materials for Shotcrete."
15. ASTM C 1604, "Standard Test Method for Obtaining and Testing Drilled Cores of Shotcrete."
16. Concrete Reinforcing Steel Institute (CRSI), "Manual of Standard Practice."
17. International Concrete Repair Institute (ICRI) 310.1R-2009 "Guideline for Surface Preparation for the Repair of Deteriorated Concrete Resulting from Reinforcing Steel Corrosion"

1.03 DEFINITIONS

A. Types of Joints

1. Construction Joint

- a. The surface which concrete has been placed and new shotcrete is to adhere, but has become too rigid that the new shotcrete cannot be incorporated into the previously placed shotcrete.

1.04 SYSTEM DESCRIPTION

(Not Used)

1.05 SUBMITTALS

- A. Contractor Qualifications. The Contractor shall submit with his bid certification that he has been actively engaged with satisfactory

results in the cementitious rehabilitation of sewers using shotcrete construction for at least 5 years.

1. Use nozzle men having current certification in accordance with guidelines of ACI 506.3R for type of shotcrete required.

Submit the following prior to the start of work or as otherwise specified herein, and in accordance with Section 100, General Provisions of the City of Columbus Construction and Material Specifications, Special Provisions, and Section SS-1 of the Supplemental Specifications.

- B. Product data for proprietary materials and items, including reinforcement and forming accessories, prebagged shotcrete materials, admixtures, patching compounds, curing compounds, and others requested by Engineer.
- C. Samples of materials requested by Engineer, including names, sources, and descriptions.
- D. Laboratory test reports for prebagged shotcrete materials and mix design data, 30 days minimum prior to shotcrete placement. Include complete list of materials, including admixtures and copies of test reports showing product has been successfully tested to produce shotcrete with specified properties.
- E. Nozzle men certifications in accordance with American Concrete Institute (ACI) 506.3R.
- F. Submit resumes of the superintendent, foreman, and nozzle men. Each must have experience in at least three (3) similar sewer jobs.
- G. Curing time requirements before removing bypass pumping or flow control.

1.06 QUALITY ASSURANCE

- A. Codes. Perform all work in compliance with the most recent federal, state, and local codes.
- B. Standards. All work shall be in compliance with the National Association of Sewer Service Companies (NASSCO).
- C. Testing Service. Routine testing will be performed by a testing agency engaged by the Owner or its Representative.

1. Materials and installed work may require testing and retesting at any time during progress of work. Testing and retesting of rejected materials shall be done at Contractor's expense.
 2. The Owner or its Representative will be at the site full time monitoring the Contractor's adherence to the plans and specifications of this contract. All non-conforming work shall be removed and replaced by the Contractor at no additional cost to the Owner.
- D. Preconstruction Testing. Comply with requirements of ACI 506.2 and as specified. Make three tests for each product being considered in compliance with the applicable provisions of American Society for Testing and Materials (ASTM) C 1140. The test shotcrete shall be applied to a panel sufficient in size to core five samples. Make test placements by each application crew performing shotcrete work. Reinforcing fiber for the test specimens shall match that specified for said shotcrete thicknesses on project plans and specs.
1. Take a minimum of five 3-inch outside diameter (OD) core specimens from panels for testing. Test specimens for strength in accordance with ASTM C 39. The average compressive strength shall be in accordance with 1.06 F.
- E. Testing During Construction. Test shotcrete for compressive and flexural strength by one of the following methods.
1. Test Panels. Gunned by shotcrete nozzlemen who will do production work. Make one test panel with minimum dimensions of 30" x 30" by the thickness as defined in ASTM C 1604. The shotcrete shall be applied vertical with the panel 4 feet above the ground, complying with applicable provisions of ASTM C 1140. Make test panel once each shift or once for each 50 cubic yards (cy) of shotcrete placed through nozzle, whichever is more frequent. Cure panels in accordance with ASTM C 1140, unless otherwise directed by the Engineer. Cut a minimum of five 3-inch OD cores from each panel and moisture condition in accordance with ASTM C 1604.
 2. Samples from In-Place Shotcrete. Cut five 3-inch OD cores from the lined sewer and test in accordance with ASTM C 39. Do not cut into steel reinforcement. Take a set of cores once each shift or once for each 50 cy of shotcrete placed through nozzle, whichever is more frequent. Core holes shall be completely filled in a neat,

workmanlike manner with the same shotcrete material used to line the sewer.

- F. Strength Evaluation. Shotcrete will be considered acceptable as follows.
 - 1. Mean compressive strength of any group of cores taken from structure or test panel equals or exceeds 85 percent of the specified compressive strength, with no individual core less than 75 percent of specified compressive strength.
- G. Polypropylene Fiber Reinforcing Shotcrete Manufacturer's Representative. An experienced technical representative of the Polypropylene fiber reinforcing shotcrete manufacturer shall be on site for the start of the shotcrete placement. The representative shall remain on site until satisfactory material and placement have been demonstrated to the satisfaction of the Owner, but for no less than 1 day. This service shall be provided at no cost to the Owner.
- H. The Contractor shall provide for a visual verification of the final placed product with the City by providing a full pipe inspection per SS-5, "Sewer Video Recording and Inspection".

1.07 DELIVERY, STORAGE AND HANDLING

- A. The Contractor shall be solely responsible for the proper delivery, storage, and handling of materials to prevent contamination, segregation, or damage.
 - 1. Dry process Shotcrete shall be delivered in original packaging, labeled with product identification, manufacturer, batch number and shelf life.
 - 2. Product shall be stored in weathertight enclosures to protect against moisture and contamination. Product shall be protected from direct sunlight and from freezing.
 - 3. Damaged or unsuitable products shall be promptly removed from the job site and shall be replaced with suitable materials.

1.08 PROJECT/SITE CONDITIONS

- A. Continuous circumferential lining work attempted during periods of high groundwater (March - May) will require approval by the City.

- B. Utility lines shall be kept in service during lining of the sewer to the greatest extent possible.
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| 1.09 | SEQUENCING | (Not Used) |
| 1.10 | SCHEDULE | (Not Used) |
| 1.11 | WARRANTY | |
- A. The Contractor shall guarantee all work as stated in the CMSC Section 109.13.
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|------|----------------------------------|------------|
| 1.12 | SYSTEM STARTUP | (Not Used) |
| 1.13 | INSTRUCTION OF OWNER'S PERSONNEL | (Not Used) |
| 1.14 | COMMISSIONING | (Not Used) |
| 1.15 | MAINTENANCE | (Not Used) |

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Refer to 2.03.

2.02	EXISTING PRODUCTS	(Not Used)
2.03	MATERIALS	

- B. Shotcrete Materials. Shotcrete materials shall be a dry process shotcrete, single-component, microsilica fortified, cement-based shotcrete containing polypropylene reinforcement using Liquid Membrane Forming Curing Compound.

- 1. Provide one of the following:
 - a. Sikacem 103F, as manufactured by Sika Corporation.
 - b. QUIKRETE Shotcrete MS 1228 with Polypropylene Fibers as manufactured by the Quikrete Companies.
 - c. MasterEmaco S 211SP, as manufactured by Master Builders a division of MBCC.
 - d. Reliner MSP, as manufactured by Standard Cement Materials Inc.
 - e. Geospray with AMS Post Coat Liquid, as manufactured by Milliken Infrastructure Solutions

- f. Quadex Geokrete, as manufactured by Vortex Companies
 - g. SewperCoat 2000 HS (dry mix), as manufactured by Kerneos Aluminate Technologies, Inc.
 - h. Admixtures are not permitted for use with pre-packaged materials.
2. Reinforcing Steel Primer. Provide one of the following:
- a. Sika Armatec 110, as manufactured by Sika Corporation.
 - b. Emaco P24 rebar coating, as manufactured by BASF Construction Chemicals, LLC.
 - c. Or approved equal
3. Water. Mixing and curing water should be clean and free from substances that may be injurious to concrete or steel, and potable water shall be used. The Contractor must have Owner approval and pay all fees prior to connection of his water supply lines to any fire hydrant. The Contractor shall provide the necessary gate valves, backflow preventers, and flow meter for each hydrant connection. All equipment, fittings, and valves shall be in accordance with the City of Columbus' standards. Use of water from fire hydrants and associated fees are outlined in City of Columbus Rule and Regulation No. 2009-04. A copy of this regulation is available from the Division of Water, Permit Office, (614) 645-7330.
- C. Liquid Membrane Forming Curing Compound. Liquid membrane-forming curing compound complying with ASTM C 309, Type I, Class A shall be used only where necessary and when the ambient temperature inside work area is 50 degrees or below to ensure proper curing of shotcrete as specified herein. Moisture loss shall be not more than 0.055 gr/sc when applied at 200 sf/gal.

2.04 MANUFACTURED UNITS (Not Used)
 2.05 EQUIPMENT

- A. The Contractor shall select equipment with demonstrated capability to apply shotcrete in the confined spaces and in the thicknesses required for this work using a dry mix. If reduced air volume and

pressure is required for placement, it shall be demonstrated that the shotcrete fills all open joints and cracks.

- B. Air Supply. Provide uniform, steady supply of clean, dry air to maintain constant nozzle velocity while operating blow pipe for cleaning away rebound.
- C. Dry Mix Delivery Equipment. Capable of discharging aggregate cement mixture into delivery hose under close control and maintaining continuous stream of uniformly mixed material at required velocity to discharge nozzle. Equip discharge nozzle with manually operated water injection system for directing even distribution of water to aggregate cement mixture.
 - 1. Provide water supply with uniform pressure at discharge nozzle sufficiently greater than operating air pressure to ensure complete mixing with aggregate cement mix. Provide water pump to system if line water pressure is inadequate.

2.06	COMPONENTS	(Not Used)
2.07	ACCESSORIES	(Not Used)
2.08	PREPACKAGED DRY PROCESS SHOTCRETE	

- A. Prepackaged shotcrete mix shall be used. Each packaged unit shall be used not more than 6 months from the date of manufacture. Contractor shall provide the batch numbers or other identifying information that coincides with the date of manufacture.
- B. Submit written product information to Engineer of each proposed product of shotcrete at least 15 days prior to start of work. Do not begin shotcrete application until Engineer has reviewed proposed shotcrete product information.
- C. Shotcrete products to provide normal weight shotcrete with the following properties:
 - 1. 2,000 pounds per square inch (psi) minimum 1-day compressive strength, 5,000 psi minimum 7-day compressive strength, and 9,000 psi minimum 28-day compressive strength, tested in accordance with ASTM C 42.

2.09	FABRICATION	(Not Used)
2.10	FINISHES	(Not Used)
2.11	SOURCE QUALITY CONTROL	(Not Used)

PART 3 EXECUTION

3.01 ACCEPTABLE INSTALLERS (Not Used)
3.02 EXAMINATION

- A. Contractor shall examine areas and conditions under which repair Work is to be installed and notify Engineer in writing of any conditions detrimental to the proper and timely completion of Work. Contractor shall refer to ACI 506.2, Paragraph 3.1.

3.03 PREPARATION

- A. Cleaning. All sewers to be lined shall be cleaned in accordance with Supplemental Specification Section SS-4, "Sewer Cleaning". The term "cleaned" shall mean the removal of sand, dirt, roots, grease, and any other solids or semisolid materials from the interior face of the sewer lines.
- B. Bypassing Sewage. The Contractor shall bypass the sewage around the sections of sewer to be rehabilitated. The bypass shall be made in accordance with Supplemental Specification Section SS-3, "Bypass Pumping/Flow Control".
- C. Existing Concrete. Remove unsound material prior to water blasting and shotcrete application. Chip or scarify areas to be repaired to extent necessary to provide sound substrate. Remove loose material from areas receiving shotcrete. Wet surfaces until damp but without visible free water.
1. Waterblast existing surfaces after chipping to remove remaining dirt, oil, slime, grease or other contaminants and to provide a clean surface for proper bonding of shotcrete to the sewer wall.
 2. Sand may be added to blasting water as required to adequately clean all surfaces provided that sand is collected and removed from the sewer and not allowed to wash downstream.
- D. Infiltration. Shotcrete shall not be placed where any free running water is present. Leaks shall be stopped by use of cementitious grout and chemical grout as specified in Supplemental Specification Section SS-6, "Chemical Grouting" and SS-7, "Cementitious Grouting". All infiltration within the sewer to be continuously lined shall be stopped at no additional cost to the Owner.

- E. Grout Injection (Cementitious). Detection and repair of voids outside the existing sewer wall shall be completed prior to lining in accordance with Supplemental Specification Section SS-7, "Cementitious Grouting".
- F. Laterals. Lateral sewer pipes protruding into the main sewer shall be trimmed flush with the inside of the main sewer wall prior to lining. Trimming must be done in a neat, workmanlike manner, causing no damage to the lateral pipe beyond the inside face of the main sewer. Point repairs shall be made as needed around laterals to ensure a smooth, watertight opening following lining of the main.

3.04 ERECTION (Not Used)
 3.05 INSTALLATION

A. Joints

- 1. Locate and install construction joints so as not to impair strength and continuity of the lined sewer. Place construction or "end of day" joints perpendicular to the centerline of the pipe. Construction joints shall not be tapered.
 - a. Prior to placing adjoining shotcrete, clean the surface, remove all laitance and roughen the surface of the concrete to a minimum of 1/4-inch amplitude

B. Shotcrete

- 1. The Contractor shall install security fence to encompass any open manholes and staging areas at each approved location. The fence shall be in accordance with CMSC Section 607, Type CL. The fence shall be removed at the completion of the shotcrete lining and the area restored to its original condition. The cost for the fencing shall be included in the bid item for shotcrete continuous lining.
- 2. Before and after placing shotcrete, inspect sewer in accordance with SS-5 "Sewer Video Recording and Inspection".
- 3. If formwork is utilized, moisten wood forms immediately before placing shotcrete.

4. Comply with ACI 304 “Recommended Practice for Measuring, Mixing, Transporting, and Placing Concrete” and as specified herein.
 5. Deposit shotcrete continuously or in layers of such thickness that shotcrete is not placed on material that has hardened sufficiently to cause the formation of seams or planes of weakness.
 - a. Shotcrete shall be placed continuously around entire circumference of the pipe. The Contractor may propose an alternative application sequence for approval by the Engineer during construction. Rebound from shotcrete application shall be completely removed from the pipe. In no case shall rebound be worked into shotcrete which has cured.
 - b. No rebound or previously expended material shall be used in the shotcrete mix.
 - c. The Contractor shall remove all overspray or rebound prior to final set and before placement of shotcrete material on adjacent surfaces. The shotcrete applicator shall be accompanied by a blow pipe operator at all times in order to maintain a clean surface for shotcrete application.
 - d. Shotcrete shall be applied in one or more layers to such total thickness and lines as required. Unless otherwise specified or detailed, all cavities, depressions, washouts and similar failures shall be rebuilt.
- C. Prior to the application of the first layer of shotcrete, the Contractor shall furnish and install adequate ground wires, measuring pins, or other approved means to establish the thickness, surface planes, and finish lines of the shotcrete. The Contractor shall maintain specified tolerances by keeping ground wires secure and taut.
1. Pins shall be noncorrosive and so designed as not to cause infiltration of water through the shotcrete. Pins shall be installed on 5-foot centers in each direction, and at other locations as may be directed by the Engineer.

- D. Protect shotcrete work from physical damage or reduced strength by frost, freezing, or low temperatures in compliance with ACI 306 and as specified.
 - 1. When air temperature has fallen to or is expected to fall below 40 degrees Fahrenheit (°F.) (4 degrees Celsius [°C.]), uniformly heat water and aggregates before mixing to obtain a shotcrete mixture temperature of not less than 50 °F. (10°C.) and not more than 80°F. (27°C.) at point of placement.
 - 2. Do not use frozen materials or materials containing ice or snow. Do not place shotcrete on frozen subgrade or on subgrade containing frozen materials.
 - 3. Do not use calcium chloride, salt, and other materials containing antifreeze agents or chemical accelerators unless accepted in mix designs.

- E. When hot weather conditions exist that would seriously impair quality and strength of concrete, place shotcrete in compliance with ACI 305 and as specified.
 - 1. Cool ingredients before mixing to maintain shotcrete temperature at time of placement below 90°F. (32°C.). Mixing water may be chilled, or chopped ice may be used to control temperature provided water equivalent of ice is calculated to total amount of mixing water.
 - 2. Use water reducing retarding admixture (Type D) when required by high temperatures, low humidity, or other adverse placing conditions.

- F. After the body coat has been placed, the surface shall be trued with a thin-edged screed to remove high areas and expose low areas. Low areas shall be properly filled with shotcrete to ensure a true, flat surface.

3.06	APPLICATION	(Not Used)
3.07	CONSTRUCTION	(Not Used)

3.08 REPAIR/RESTORATION

- A. Remove and replace shotcrete that lacks uniformity, that exhibits segregation, honeycomb overspray, rebound, or delamination, or

that contains dry patches, single voids in excess of ½-inch in any direction, or sand pockets.

3.09 RE-INSTALLATION (Not Used)

3.10 FIELD QUALITY CONTROL

- A. It is anticipated that humidity levels within the sewer will be adequate for curing of shotcrete. However, the Contractor will be responsible for preventing any premature drying of the shotcrete for not less than 7 days with particular attention to repairs exposed by excavation and at manholes.
- B. Perform special curing of shotcrete by moist curing, membrane curing compound, or moisture retaining cover, as approved by the Engineer.
- C. Flow Reinstatement. Contractor shall allow adequate time for curing before removing bypass pumping or flow control.
- D. The Contractor shall provide verification of the final placed product with the City by providing photos of the repaired areas, which are to be to the satisfaction of the Owner and Engineer.

3.11 ADJUSTING (Not Used)

3.12 CLEANING

- A. Should excess shotcrete travel into downstream sections of the sewer it shall be the responsibility of the Contractor to remove at no expense to the Owner.

3.13 DEMONSTRATION (Not Used)

3.14 PROTECTION (Not Used)

3.15 SCHEDULES

- A. Measurement and Payment
 - 1. This item of work shall include all necessary protruding lateral removal and repair, infiltration stoppage, water blasting, water plug, shotcrete, reinforcements, curing, equipment, labor, testing, clean-up, and all other expenses whether specifically mentioned or not to complete the shotcrete pipe rehabilitation.

2. Payment will be made at the unit price bid per linear foot as measured along the centerline of the rehabilitated sewer repair based on the specified coating thicknesses.

<u>ITEM</u>	<u>UNIT</u>	<u>DESCRIPTION</u>
SS-14A	LF	Shotcrete Continuous Lining – XX"
SS-14A	LF	Shotcrete Continuous Lining - XX"

END OF SECTION