

## ITEM 499 - CONCRETE - GENERAL

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**499.01 Description.** This work shall consist of proportioning and mixing Portland cement concrete.

**499.02 Materials.** Materials shall be:

Fine aggregate *	703.02
Fly ash**	705.13
Ground granulated blast-furnace (GBBF) slag	705.14
Coarse aggregate	703.02
Portland cement	701.01, 701.02, 701.03, 701.04, 701.05, 701.06, 701.09**, 701.10**
Shrinkage-compensating cements	701.08
Air entraining admixture	705.10
Chemical admixture for concrete	705.12***

\*703.02 natural sand is required in Items 451, 452, 453, 611, and 511 deck slabs.

\*\*May be used in all items between April 1 and *November 1*.

\*\*\*Admixtures shall contain no more than 50 parts per million chloride ions by weight of cement.

The brand and kind of all concrete materials for any one item may be changed only by permission of the Engineer.

Water used in concrete shall be free from sewage, oil, acid, strong alkalis or vegetable matter, and also shall be free from clay and loam. Water which is potable is satisfactory for use in concrete.

**499.03 Proportioning.** Proportioning shall be based on predetermined cement content, water cement ratio, air entrainment, and specified compressive strength as indicated in the tables below. Except as otherwise provided herein, each cubic yard of

concrete shall contain the specified cement factor as determined by a yield test. The yield shall be accurate within  $\pm 1$  percent. The water cement ratio shall not exceed the maximum specified. Below this limit the quantity of water shall be adjusted to meet the slump requirements. The compressive strengths shall be that specified for any given placement.

Unless otherwise specified, in the concrete table, concrete shall contain 5 to 8 percent of entrained air.

**Note A:** Slump shall be maintained within the allowable slump range in the following table. Slump, when tested in accordance with ASTM C 143, shall be maintained within these allowable slump ranges, unless otherwise specified in the plans. When slump is found to exceed the limit of the allowable slump range but is within the occasional maximum slump limit, occasional loads of concrete may be used, provided an immediate adjustment is made in the mixture to reduce the slump of succeeding loads within the allowable slump range shown. No concrete shall be used in the work that has a slump greater than that shown as an occasional maximum slump in the table.

The maximum slump for trucks with non-agitating bodies will be the maximum allowable slump range as shown in the concrete table.

#### CONCRETE TABLE FOR SLUMP/AIR LIMITS

(See Note A) Type of Concrete	Allowable Slump Range inches* (mm)	Occasional Max. Slump inches** (mm)	Air
305 P.C.C. Base - Arterial	1-3 (25-76)	4 (101)	3-6%
306 P.C.C. Base - Residential	1-4 (25-101)	5 (127)	3-6%
451 R.P.C.C. Pavement	1-3 (25-76)	4 (101)	5-8%
(for slip form paving)	0-3 (0-76)	3 (76)	5-8%
452 P.P.C.C. Pavement	1-3 (25-76)	4 (101)	5-8%
(for slip form paving)	0-3 (0-76)	3 (76)	5-8%

511 Structures	1-4 (25-101)	5 (127)	5-8%
511 Structures (superstructure)	2-4 (50-101)	4 (101)	5-8%
511 Structures (Type K)	4-6 (101-152)	6 (152)	4-8%
601	1-4 (25-101)	5 (127)	5-8%
602	1-4 (127)	5	5-8%
603	1-4 (25-101)	5 (127)	5-8%
604	1-4 (25-101)	5 (127)	5-8%
608 Walks and Steps	1-4 (25-101)	5 (127)	5-8%
(for slip form paving)	0-2 (0-50)	2 (50)	5-8%
609 Curbs	0-4 (0-101)	5 (127)	5-8%
(for slip form paving)	0-2 (0-50)	2 (50)	5-8%
611 Approach Slabs	1-3 (25-76)	4 (101)	5-8%
612 Concrete Median and Traffic Island	1-4 (25-101)	5 (127)	5-8%
613 Traffic Dividers	0-2 (0-50)	2 (50)	5-8%

\* Slump may be increased to six inches provided the increase is achieved by the addition of a chemical admixture meeting the requirements of Section 705.12, Type F or G.

\*\* This slump may be increased to seven inches provided the increase is achieved by the addition of a chemical admixture meeting the requirements of Section 705.12, Type F or G.

Tests on the plastic concrete for pavement shall be made at the placement site or at a location designated by the Engineer after it has been placed on the prepared surface. Tests for structure concrete shall be made at the site of the work at the time the concrete is being placed.

The proportioning of the materials shall be the responsibility of the Contractor and/or Concrete Supplier, and shall be in accordance with the ACI Standard "Recommended Practice for Selecting Proportions for Normal Weight Concrete" (ACI 211.11). The proportioning shall be based on developing the specified compressive strength at 28 days as indicated in the CONCRETE TABLE.

The proportioning of the materials shall use the water-cement ratio, slump range, air entrainment range, and cement content specified in the concrete table. High-early-strength concrete is not specified, but desirable to expedite the work. The Contractor may use, at his own expense, high-early-strength cement, *additional cement*, approved chemical admixtures, or a combination of these materials. The Contractor may use high early-strength concrete at his own expense when not specified in the plans.

The Contractor and/or Concrete Supplier shall provide certified test data in accordance with Section 101.10 from a recognized testing laboratory that shows the proposed mix design will meet the average strength requirement. A recognized testing laboratory is any laboratory regularly inspected by the Cement and Concrete Reference Laboratory. All proposed mix designs shall be approved by the Engineer and/or Laboratory and maintained on file with the owner Division. Any adjustments shall be approved by the Engineer. Mixes shall be submitted for review and approval annually.

All concrete used shall be that of an approved mix design. If no mix design has been approved then the contractor shall submit a mix design to the city at the preconstruction conference or at least 10 working days in advance of placement for approval by the Director. Adjustments to approved mix designs shall be approved by the Engineer.

**Concrete Table  
Quantities per Cubic Yard**

<b>Class of Concrete</b>	<b>Yield</b>	<b>Cement Content (lb) (kg)</b>	<b>Minimum Water Cement Ratio</b>	<b>Specified Comp Strength f'c at 28 days psi (mPa)</b>
CLASS A	± 1%	280 (166)	1.04	N/A
CLASS B	± 1%	380 (225)	0.75	1800 (12)
CLASS C	± 1%	600 (356)	0.48	4000 (28)
CLASS E	± 1%	510 (302)	0.59	3000 (21)
CLASS S	± 1%	715 (424)	0.44	4500 (31)

If the Contractor elects to use Section 701.08, 701.09 or 701.10 cement, the batch weight of the fine and coarse aggregates will be adjusted to allow for the lower specific gravity of these types of cement. The Engineer shall be contacted for assistance in making this adjustment and must approve the mix design.

At any time during the construction period, the proportioning of the aggregates may be varied by the contractor if approved by the engineer. Relative weights of fine and coarse aggregates may be varied in order to insure a workable mix within the specified slump range and to control the yield, but in no case should the fine aggregate exceed 50 percent of the total aggregate weight. However, the total weight of aggregate per cubic yard shall not be changed except as provided in the preceding paragraph as for the following conditions or both.

1. For batch weights, the weights shall be corrected to compensate for moisture contained in the aggregate at the time of use.
2. If it is found impossible to prepare concrete of the proper consistency without exceeding the maximum water-cement ratio specified, a water reducing admixture conforming to requirements of Section 705.12 shall be used or the cement content shall be increased. However, the Contractor shall not be compensated for the admixture or additional cement which may be required by reason of such adjustment.
3. Unit weight determinations shall be made and the yield shall be calculated and maintained in accordance with ASTM C 138. Based on these determinations the batch weights will be adjusted when necessary. However the specified cement content shall be maintained within a tolerance of ± 1 percent and the maximum water-cement ratio shall not be exceeded.

4. The amount of mixing water shall be adjusted for the moisture contained in the aggregates and for the moisture which they will absorb, in order to determine the amount of water to be added at the mixer.
5. An approved water reducing set retarding admixture meeting the requirements of Section 705.12, Type D shall be required for concrete when the temperature exceeds a nominal temperature of 75° F (24° C)

**499.031 Other Proportioning Options.** The Contractor may at his discretion, substitute one of the following options for the concrete items specified:

**Option 1.** The cement content may be reduced as much as 15 percent by weight with the substitution of an equivalent weight of fly ash meeting the requirements of Section 705.13. The water-cement ratio shall be based on the combined weight of cement and fly ash. Fly ash will not be permitted in concrete mixes using Type K cement (Section 701.08). This option is available to all classes of concrete mixes.

**Option 2.** The cement content for Class C and Class S concrete mixes may be reduced as much as 50 pounds per cubic yard (30 kg/m<sup>2</sup>), with the substitution of an equivalent volume of aggregate, provided the Contractor uses an approved water reducing admixture meeting the requirements of Section 705.12, Type A or Type D. For Class E the reduction is 30 pounds per cubic yard (17.8 kg/m<sup>2</sup>). Class A or B mixes require approval of the Engineer under this option.

**Option 3.** GGPBF slag may be used in all classes of concrete, and the cement content reductions described in Option 2 apply. GGBF slag may comprise up to 40 percent of the cementitious materials content by mass. From October 15th to April 1st, GGBF slag may comprise up to 30 percent of the cementitious material content. Higher GG slag dosages may be used with the approval of the Engineer.

The use of Type K (Section 701.08), Type IP (Section 701.09) or Type IPA (Section 701.10) cement is not permitted under either of the above options. All admixtures used in the concrete mixture must be compatible and shall be dispensed in accordance with the manufacturer's recommendations.

If Portland Cement with fly ash as an additive is used as described under Option 1, the mix design shall be used only between April 1 and November 1, unless otherwise authorized by the Director. If either of the above options is used, an approved water reducing set retarding admixture meeting the requirements of 705.12, Type D shall be used if the concrete temperature exceeds a nominal temperature of 75° F (24° C).

The proportioning of the materials under Options 1, 2 and 3 shall be the responsibility of the Contractor and/or Concrete Supplier, and shall be in accordance with the ACI Standard "Recommended Practice for Selecting Proportions for Normal Weight Concrete" (ACI 211.11). The proportioning shall be based on developing an average compressive strength as specified in the CONCRETE TABLE in Section 499.03.

For mixes used in ODOT Supplemental Specifications 850, and using Options 1, 2 and 3, data shall be provided for all requirements with Supplement 1045. The testing for Absorption, Scaling Resistance and Volume Change will not be required for mixes used in ODOT Supplemental Specification 850.

Only one source of fly ash shall be used in any one structure unless otherwise authorized by the Director. Bulk fly ash or GGBF shall be stored in waterproof bins.

No cement reduction shall be permitted under either option above in concrete mixes designed or intended to obtain high-early-strength.

#### **499.032 Class FS & MS Concrete.**

**Class FS.** This mixture is a fast setting portland cement concrete for accelerated setting and strength development. The minimum cement content shall be 900 pounds per cubic yard (534 kg/m<sup>3</sup>) and the maximum water-cement ratio shall be 0.40. The rigid replacement may be opened to traffic after four hours provided test beams have attained a modulus of rupture of 400 psi (2.7 MPa).

The concrete shall be kept plastic by means of a Section 705.12, Type B or D admixture until the surface has been textured. The Type B or D admixture shall be used in accordance with the manufacturer's recommendations.

Calcium chloride shall be added and mixed with each batch of concrete just prior to placement. If calcium chloride with 94-97 percent purity is used, the addition rate shall be 1.6 percent by weight of the cement. If calcium chloride with 77-80 percent purity is used, the addition rate shall be 2.0 percent by weight of cement. When calcium chloride in a water solution is used, the water used shall be considered as part of the concrete mixing water and appropriate adjustments shall be made for its inclusion in the total concrete mixture.

Any other approved accelerating admixture may be used at the rate recommended by the manufacturer provided it will produce the required strength in the allotted time.

Immediately after the curing compound has been applied, the replacements shall be covered with polyethylene sheeting and further covered with building board as specified in ASTM C 208. The building board shall be wrapped in a black polyethylene sheeting and placed tight against the surrounding concrete and weighted down to protect the fresh concrete from the weather.

**Class MS** This mixture is a moderate-setting portland cement concrete for accelerated strength development. The rigid replacement may be opened to traffic after 24 hours provided test beams have attained a modulus of rupture of 400 psi (2.7 MPa). The minimum cement content shall be 800 pounds per cubic yard (475 kg/m<sup>3</sup>) and the maximum water-cement ratio shall be 0.43

The proportioning of the concrete materials to meet the requirements of each class of rigid replacement concrete specified shall be responsibility of the Contractor. The coarse aggregate may be any one of the following sizes: No. 57, No. 6, No. 67, or No. 8. When No. 8 size is used, the entrained air content shall be 6 to 8 percent. Otherwise the entrained air content shall be 4 to 8 percent.

The Engineer's approval of the concrete mix design will be based on the Contractor's submitted proportions and the foregoing information.

The average 28 day compressive strength for Class FS or MS concrete shall be as specified in the plans. If no strength is specified the minimum acceptable strength shall not be less than that specified in the table above for the intended use.

**499.04 Equipment.** Equipment shall be as follows:

1. **Batching Plants.** Each plant shall be constructed and operated so that no intermingling of materials occurs prior to batching. The plant shall have weighing mechanisms which provide either visible means of checking weights or a printed record. Dispensing mechanisms for water and admixtures shall have a visible means of checking quantities or shall produce a printed record.

Weighing mechanisms used for cement and aggregates shall weigh to an accuracy such that the weight indicated on the scale or printed ticket is within  $\pm 0.5$  percent of the correct weight. Devices for weighing or metering water shall measure to an accuracy of  $\pm 1.0$  percent throughout the range used.

All weighing and metering devices shall have been checked and their accuracy attested to within the 12-month period immediately prior to their use. This service may be performed by the Sealer of Weights and Measures or a scale servicing company. In lieu of the preceding requirements, the concrete batch facilities may be approved if the plant has been inspected and approved by the Ohio Department of Transportation within the calendar year being used.

Ten 50-pound (22.7 kg) standard test weight or services of a scale serving company shall be readily available for testing the weighing devices at the batch plant. All weights used in testing the weighing devices shall be sealed every 3 years by the Ohio Department of Agriculture.

Weighing and dispensing devices shall be tested as often as the Engineer may deem necessary to assure their continued accuracy.

2. **Mixers.** Mixers and agitators shall conform to Paragraphs 10, 11.2, 11.5, and 11.6 of AASHTO M 157, except that mechanical counters are permitted.

When a truck mixer is used for complete mixing, each batch of concrete shall be mixed for not less than 70 revolutions of the drum or blades at the rate of rotation designated on the metal plate on the mixer as mixing speed. Transit mix counters shall indicate mixing speed revolutions and agitating revolutions.

Bodies of non-agitating hauling equipment for concrete shall be smooth, mortar-tight, metal containers, and shall be capable of discharging the concrete at a satisfactory controlled rate without segregation. Covers shall be provided when required by the Engineer. Trucks having dump bodies with rounded corners and no internal ribs or projections will be permitted for non-agitating hauling.

**499.05 Handling, Measuring and Batching Materials.** Aggregates from different sources and of different gradings shall not be stockpiled together. Aggregates that have become segregated, or mixed with earth or foreign material, shall be reworked or cleaned as directed by the Engineer, or rejected. Coarse aggregate shall be maintained with a uniform moisture content.

The fine aggregate and each size of coarse aggregate shall be separately weighed into hoppers in the respective amounts set by the Engineer as outlined in Section 499.03. Separate weighing devices shall be used for weighing the cement and fly ash.

Batching shall be so conducted as to result in the weights of each material within a tolerance of  $\pm 1.0$  percent for cement and  $\pm 2.0$  percent for aggregates. Water shall be measured either by weight or volume to within a tolerance of  $\pm 1.0$  percent. Admixtures

shall be dispensed to within  $\pm 3.0$  percent of the desired amount. Methods and equipment for adding air-entraining agent or other admixture into the batch, when required, shall be approved by the Engineer.

**499.06 Mixing Concrete.** The concrete may be mixed in a central mix plant, truck mixers or at the site if approved by the Engineer. The mixer shall be of an approved type.

Mixing time for central mixers shall not be less than 60 seconds. Mixing time begins when all materials are in the drum and ends when the discharge begins. Transfer time in multiple drum mixers is included in mixing time. The contents of an individual mixer drum shall be removed before a succeeding batch is emptied therein.

Ready-mixed concrete shall be mixed and delivered in accordance with Section 499.04(2). Mixed concrete from the central mixer shall be transported in truck mixers, or truck agitators. The concrete shall be delivered to the site of the work and discharge shall be completed within one hour after the combining of the cement and the water. For trucks having non-agitating bodies, the concrete shall be delivered and discharge shall be completed within 30 minutes after combining of the cement and the water. If an approved set-retarding (Section 705.12, Type B) or a water-reducing and set-retarding (Section 705.12, Type D or G) admixture is used at the Contractor's expense, discharge shall be completed within 90 minutes after the combining of the water and the cement. This discharge time shall not exceed one hour for trucks with non-agitating bodies.

When concrete is delivered in transit mixers or agitators, additional water within the limits specified may be added and sufficient mixing performed to adjust the slump and to regenerate the specified air content throughout the batch, provided all these operations are performed prior to discharging any of the batch and within the above time limitations. When making these adjustments, the concrete shall be mixed a minimum of 30 revolutions at mixing speed.

Retempering after the start of discharge is permitted by the use of approved admixtures (Section 705.12, Type F or G) when approved by the Engineer.

Admixtures containing more than 50 parts per million chloride by weight of cement will be permitted only when provided for in the contract, or upon written permission of the Director.

The procedure for making and testing concrete beams shall be in accordance with requirements of ODOT Supplement 1023 on file in the Office of the *Transportation Division*.

**499.07 Shrinkage-Compensating Cement.** This material is an expansive cement, Type K which when mixed with water forms a paste that, after setting, tends to increase in volume to a significantly greater degree than portland cement paste; used to

compensate for volume decrease due to shrinkage or to induce tensile stress reinforcement.

Water cement ratio shall be adjusted to compensate for the compressive strengths of expansive cement concrete. The required water-cement ratio for any mix shall be increased to 0.50, unless otherwise designated on the plans. Note to the designer, if expansive cement is specified and specific compressive strengths are desired, than the water-cement ratio should be indicated in the plans or supplemental specifications.

Whenever an expansive cement (Type K) has been specified the basis of payment will be made at the contract unit price for the type of concrete specified in the plan. The Item Description shall include "701.08 (Type K)" which is to be added to the description. Procedures as set forth in ACI-223-83 and ASTM C845-80 specifications shall govern the use, placing, finishing and curing of expansive type concrete.

**499.08 Concrete Test Specimens.** The City shall take representative field samples to verify conformance to the strength requirements set forth in the "Concrete Table" in Section 499.03. One set of 3 test cylinders will be made for each 50 cubic yards (38 m<sup>3</sup>) for structure concrete, 100 cubic yards (76 m<sup>3</sup>) for miscellaneous concrete including but not limited to walls, curbs, steps, and 250 cubic yards (191 m<sup>3</sup>) for residential and arterial bases and pavements.

Test specimens will be made and cured in accordance with ASTM C-31. During the initial 24 hour curing period, it shall be the sole responsibility of the contractor to furnish an acceptable curing environment to meet the specification requirements for moisture and temperature control for the test cylinders. This may be accomplished by use of wooden boxes with thermostatically controlled heating elements, on site project buildings or trailers, or other means acceptable to the engineer or his agent. Two cylinders shall be tested at 28 days for acceptance and one shall be tested at 7 days for information. Cylinders will be tested in accordance with ASTM C-39.

**499.09 Quality Control and Assurance.** When the 7 day information sample yields a strength lower than 70 percent of the required strength ( $f'_c$ ) (MPa), the contractor and suppliers will be notified to investigate the production and placement operations for potential problems. Should the 28 day test yield strength results below the required strength, the Engineer/Laboratory may order production of this class mix discontinued until corrective adjustments have been made to the City's satisfaction. Strength evaluation will be based on the following criteria:

The strength level of the concrete will be considered satisfactory so long as the averages of all sets of three consecutive strength results equal or exceed the specified strength ( $f'_c$ ) (MPa) in the "Concrete Table", and no individual test result falls below the specified strength of  $f'_c$  (MPa) by more than 500 psi (0.3 MPa).

When only 1 set of cylinders is made to represent a placement, a test will be defined as the average of the two 28 day test results.

An approved mix design may be suspended if the average compressive strength at 28 days are not being maintained, as determined through production testing by the City.