

**Item No. 403S**  
**Concrete for Structures**

**403S.1 Description**

This item shall govern quality, storage, handling, proportioning and mixing of materials for hydraulic cement concrete construction of buildings, bridges, culverts, slabs, prestressed concrete and incidental appurtenances.

This specification is applicable for projects or work involving either inch-pound or SI units. Within the text, the inch-pound units are given preference followed by SI units shown within parentheses.

**403S.2 Submittals**

The submittal requirements of this specification item may include:

- Mix design option(s) of the class of concrete required on the project,
- The supplier of the concrete mix design(s) and type of mixing equipment, and
- Type of admixtures to be used with the concrete mixes.

**403S.3 Materials**

Concrete shall be composed of hydraulic cement or hydraulic cement and supplementary cementing materials, water, aggregates (fine and coarse), and admixtures proportioned and mixed as hereinafter provided to achieve specified results.

**A. Cementitious Materials**

Hydraulic cement shall conform to ASTM C 150, Type I (General Purpose), Type II (General Purpose with Moderate Sulfate Resistance) and Type III (High Early Strength). Type I shall be used when none is specified or indicated on the drawings. Type I and Type III cements shall not be used when a Type II cement is specified or indicated on the drawings. Type III cement may be used in lieu of a Type I cement, when the anticipated air temperature for the succeeding 12 hours will not exceed 60oF (15.6oC). A Type III cement shall only be used in precast concrete or when otherwise specified or allowed. All cement shall be of the same type and from the same source for a monolithic placement.

Unless otherwise specified the cementitious material content shall be limited to no more than 700 lbs. per cubic yard (417 kg per cubic meter). When supplementary cementing materials are used, cement is defined as "cement plus supplementary cementing material." Supplementary cementing materials include fly ash (DMS 4610), ultra-fine fly ash (DMS-4610), ground granulated blast furnace slag grade 100 or 120 (DMS-4620), silica fume (DMS-4630) and metakaolin (DMS-4635).

Supplementary cementing materials shall not be used when white hydraulic cement is specified.

Class C flyash shall not be used in sulfate-resistant concrete.

Hydraulic cement manufactured in a cement kiln fueled by hazardous waste shall be considered as an approved product if the production facility is authorized to operate under regulation of the Texas Commission on Environmental Quality (TCEQ) and the U. S. Environmental Protection Agency (EPA). Supplier shall provide current TNRCC and EPA authorizations to operate the facility.

When sulfate-resistant concrete is required for a project, mix design options 1, 2, 3 or 4 presented in Section 403S.8, "Mix Design Options" shall be used to develop appropriate mix design utilizing Type I/II, II, V, IP or IS cement.

**B. Mixing Water**

Water for use in concrete and for curing shall be potable water free of oils, acids, organic matter or other deleterious substances and shall not contain more than 1,000 parts per million of chlorides as Cl or sulfates as SO<sub>4</sub>.

Water from the City of Austin will not require testing. Contractor may request approval of water from other sources. Contractor shall arrange for samples to be taken from the source and tested at the Contractor's expense. When water from other sources is proposed, test reports shall be provided that indicates compliance with Table 1 before use.

Contaminant	Test Method	Maximum Concentration (ppm)
Chloride (CL) Prestressed concrete Bridge decks & superstructure All other concrete	ASTM D-512	500 500 1,000
Sulfate (SO <sub>4</sub> )	ASTM D-516	1,000
Alkalies (NA <sub>2</sub> O + 0.658 K <sub>2</sub> O)	ASTM D-4191 & D-4192	600
Total Solids	AASHTO T-26	50,000

Water that has an adverse effect on the air-entraining agent or any other chemical admixture or on strength or time of set of the concrete shall not be used. Water used in white Portland cement concrete shall be free from iron and other impurities, which may cause staining, or discoloration.

**C. Coarse Aggregate**

Coarse aggregate shall consist of durable particles of crushed or uncrushed gravel, crushed blast furnace slag, crushed stone or combinations thereof; free from frozen material or injurious amounts of salt, alkali, vegetable matter or other objectionable material either free or as an adherent coating. When white hydraulic

cement is specified, the coarse aggregates used in the concrete shall be light colored. Quality shall be reasonably uniform throughout.

The coarse aggregate from each source shall not contain more than 0.25 percent by weight of clay lumps, nor more than 1.0 percent by weight of shale nor more than 5 percent by weight of laminated and/or friable particles when tested in accordance with TXDOT Test Method TEX-413-A. The coarse aggregate from each source shall have a wear of not more than 40 percent when tested in accordance with TXDOT Test Method TEX-410-A.

Unless otherwise indicated on the drawings, the coarse aggregate from each source shall be subjected to 5 cycles of the soundness test conforming to TXDOT Test Method TEX-411-A. The loss shall not be greater than 12 percent when sodium sulfate is used or 18 percent when magnesium sulfate is used.

Coarse aggregate shall be washed. The Loss by Decantation (TXDOT Test Method TEX-406-A), plus allowable weight of clay lumps, shall not exceed 1 percent or the value indicated on the drawings or in the project manual, whichever is less. If material finer than the # 200 (75 micrometer) sieve is definitely established to be dust or fracture of aggregates made primarily from crushing of stone, essentially free from clay or shale as established by Part III of TXDOT Test Method TEX-406-A, the percent may be increased to 1.5. When crushed limestone coarse aggregate is used in concrete pavements, the decant may exceed 1% but not more than 3% if the material finer than the # 200 (75 micrometer) sieve is determined to be at least 67% calcium carbonate in accordance with TxDoT Test Method Tex-406-A, Part III.

The coarse aggregate factor may not be more than 0.82; however, when voids in the coarse aggregate exceed 48 percent of the total rodded volume, the coarse aggregate factor shall not exceed 0.85. The coarse aggregate factor may not be less than 0.68 except for a Class I machine extruded mix that shall not have a coarse aggregate factor lower than 0.61.

When exposed aggregate surfaces are required, the coarse aggregate shall consist of particles with at least 40 percent crushed faces. Uncrushed gravel, polished aggregates and clear resilient coatings are not acceptable for exposed aggregate finishes.

When tested by approved methods, the coarse aggregate including combinations of aggregates when used, shall conform to the grading requirements shown in Table 2.

Grade	Nom. Size	2-1/2" (62.5 mm)	2" (50 mm)	1 1/2" (37.5 mm)	1" (25 mm)	3/4" (19 mm)	1/2" (12.5 mm)	3/8" (9.5 mm)	No. 4 (4.75 mm)	No. 8 (2.36 mm)
1	2" (50 mm)	100	80-100	50-85		20-40			0-5	
2 (467)*	1 1/2" (37.5 mm)		100	95-100		35-70		10-30	0-5	
3	1" (50 mm)		100	95-100		60-90	25-60		0-5	

4 (57)*	1" (50 mm)			100	95-100		25-60		0-10	0-5
5 (67)*	3/4" (19 mm)				100	90-100		20-55	0-10	0-5
6 (7)*	1/2" (12.5 mm)					100	90-100	40-70	0-15	0-5
7	3/8" (9.5 mm)						100	70-95	0-25	
8	3/8" (9.5 mm)						100	95-100	20-65	0-10

Notes:

1. Recycled crushed concrete fine aggregate shall be limited to a maximum of 20% of the fine aggregate.
2. The use of recycled crushed hydraulic cement concrete as a coarse aggregate shall be limited to Concrete Classes A, B and D (see Table 5).

D. Fine Aggregate

Fine aggregate shall be washed and consist of clean, hard, durable and uncoated particles of natural or manufactured sand or a combination thereof, with or without a mineral filler. When white hydraulic cement is specified, the fine aggregates used in the concrete shall be light colored. Quality shall be reasonably uniform throughout. It shall be free from frozen material or injurious amounts of salt, alkali, vegetable matter or other objectionable material and it shall not contain more than 0.5 percent by weight of clay lumps in accordance with TEX-413-A. When subjected to color test for organic impurities per TXDOT Test Method TEX-408-A, it shall not show a color darker than standard.

Unless indicated otherwise on the drawings the acid insoluble residue of fine aggregate used in slab concrete subject to direct traffic shall not be less than 60 percent by weight (mass) when tested conforming to TXDOT Test Method TEX-612-J.

Unless indicated otherwise on the Drawings, fine aggregate shall be blended, when necessary, to meet the acid insoluble residue requirement.

When blending the following equation shall be used:

$$\text{Acid Insoluble (\%)} = \{(A1)(P1) + (A2)(P2)\} / 100$$

Where:

A1 = acid insoluble (%) of aggregate 1,

A2 = acid insoluble (%) of aggregate 2,

P1 = % by weight of A1 of the fine aggregate blend, and

P2 = % by weight of A2 of the fine aggregate blend.

When tested in accordance with TxDOT Test Method Tex-401-A, the fine aggregate, including mineral filler and combinations of aggregates, when used, shall conform to the grading requirements shown in Table 3.

Table 3: Fine Aggregate Gradation Chart1 (Grade 1 - Percent Passing)							
3/8 (9.5 mm)	No. 4 (4.75 mm)	No. 8 (2.36 mm)	No. 16 (1.18 mm)	No. 30 (600 µm)	No. 50 (300 µm)	No. 100 (150 µm)	No. 200 (75 µm)
100	95-100	80-100	50-85	25-65	10-351	0-10	0-32

Notes:

1. Recycled crushed concrete fine aggregate shall be limited to a maximum of 20% of the fine aggregate.
2. The use of recycled crushed hydraulic cement concrete as a fine aggregate shall be limited to Concrete Classes A, B and D (see Table 5).
3. 6 to 35 when sand equivalent value is greater than 85.
4. 0 to 6 for manufactured sand.

Sand equivalent per TXDOT Test Method TEX-203-F shall not be less than 80 nor less than otherwise indicated on the drawings, whichever is greater.

The fineness modulus will be determined by adding the percentages by weight retained on sieve Nos. 4, 8, 16, 30, 50 and 100 (4.75 mm, 2.36 mm, 1.18mm, 600 µm, 300 µm, and 150 µm) and dividing the sum of the six sieves by 100. For all classes of concrete except K (see Table 5), the fineness modulus shall be between 2.30 and 3.10. For Class K concrete, the fineness modulus shall be between 2.40 and 2.90, unless indicated otherwise on the Drawings.

E. Mineral Filler

Mineral filler shall consist of stone dust, clean crushed sand or other approved inert material. When tested in accordance with TxDOT Test Method Tex-401-A, it shall conform to the following gradation:

Passing the No. 30 (600 µm) Sieve 100 percent

Passing the No. 200 (75 µm) Sieve 65 to 100 percent

F. Mortar and Grout

Unless otherwise specified, indicated on the drawings or approved by the Engineer or designated representative mortar and grout shall consist of 1 part hydraulic cement, 2 parts finely graded sand and enough water to make the mixture plastic. When required to prevent color difference, white cement shall be added to produce color required. When required by the Engineer or designated representative, approved latex adhesive may be added to the mortar. Mortar shall be provided with a consistency such that the mortar can be easily handled and spread by trowel.

Grout shall be provided of a consistency that will flow into and completely fill all voids.

G. Admixtures

All chemical admixtures including water reducing, plasticizers and air entrainment shall conform to TxDOT DMS-4640, "Chemical Admixtures for Concrete". Calcium chloride-based admixtures shall not be approved. Admixtures shall be included in the prequalified concrete admixtures list maintained by TxDOT's Construction Division. High-range water-reducing admixtures (TxDOT Type F or G) and accelerating admixtures (TxDOT Type C or E) shall not be used in bridge deck concrete.

H. Air Entrainment

Unless indicated otherwise on the drawings, all concrete classes with the exception of Class B shall be air-entrained in accordance with Table 8. If the air content is more than 1-1/2 percentage points below or 3 percentage points above the required air, the load of concrete will be rejected. If the air content is more than 1-1/2 but less than 3 percentage points above the required air, the concrete may be accepted based on strength test results.

#### 403S.4 Storage of Materials

A. Cement, Supplementary Cementing Materials and Mineral Filler

All cement, supplementary cementing materials and mineral filler shall be stored in separate and well ventilated, weatherproof buildings or approved bins, which will protect the material from dampness or absorption of moisture. Storage facilities shall be easily accessible and each shipment of packaged cement shall be kept separated to provide for identification and inspection. The Engineer or designated representative may permit small quantities of sacked cement to be stored in the open for a maximum of 48 hours on a raised platform and under waterproof covering.

B. Aggregates

The method of handling and storing concrete aggregates shall prevent contamination with foreign materials. If the aggregates are stored on the ground, the sites for the stockpiles shall be clear of all vegetation and shall be level. Aggregates shall be stockpiled in sizes to facilitate blending. If the aggregate is not stockpiled on a hard, non-contaminant base, the bottom 6-inch (150 mm) layer of the stockpile shall not be used without recleaning the aggregate.

When conditions require the use of 2 or more grades of coarse aggregates, separate stockpiles shall be maintained to prevent intermixing. Where space is limited, stockpiles shall be separated by walls or other appropriate barriers.

Aggregate shall be stockpiled and protected from the weather a minimum of 24 hours prior to use to minimize free moisture content. When stockpiles are too large to protect from the weather, accurate and continuous means acceptable to the Engineer or designated representative shall be provided to monitor aggregate

temperature and moisture. Aggregates shall be stockpiled and handled such that segregation and contamination are minimized.

The stockpiles shall be sprinkled to control moisture and temperature as necessary. A reasonably uniform moisture content shall be maintained in aggregate stockpiles.

C. Admixtures

Admixtures shall be stored in accordance with manufacturer's recommendations and shall be protected against freezing.

D. Hot Weather Concrete Mixes

Ice may be used during hot weather concrete placement (Section 13 of Standard Specification Item No. 410S, "Concrete Structures") to lower the concrete temperature; however, the Contractor shall furnish a mix design acceptable to the Engineer or designated representative for class of concrete specified. The addition of ice shall not exceed 50% of the total mix water weight.

#### 403S.5 Measurement of Materials

Water shall be accurately metered. Fine and coarse aggregates, mineral filler, bulk cement and fly ash shall be weighed separately. Allowances shall be made in the water volume and aggregate weights during batching for moisture content of aggregates and admixtures. ~~Volumetric and weight measuring devices shall be acceptable to the Engineer or designated representative.~~ Measurement of materials in non-volumetric and volumetric mixers shall conform to Section 421.4.D of TxDot Specification Item 421, "Hydraulic Cement Concrete".

Batch weighing of sacked cement is not required; however, bags, individually and entire shipments, may not vary by more than 3 percent from the specified weight of 94 pounds (42.6 kilograms) per bag. The average bag weight of a shipment shall be determined by weighing 50 bags taken at random.

#### 403S.6 Mix Design

The Contractor shall furnish a mix design acceptable to the Engineer or designated representative for the class of concrete required in accordance with Table 5. The mix shall be designed by a qualified commercial laboratory and signed/sealed by a registered Professional Engineer, licensed in the state of Texas to conform with requirements contained herein, to ACI 211.1 or TXDOT Bulletin C-11 (and supplements thereto). The maximum water-to-cementitious material ratio identified in Table 5 for specific classes of concrete shall not be exceeded.

A higher-strength class of concrete with equal or lower water-to-cementitious-material ratio may be substituted for the specified class of concrete.

The mix design shall be over-designed in accordance with Table 5 in order to account for production variability and to ensure minimum compressive strength requirements are met.

Allowable mix design options are presented in Section 403S.8.

The Contractor shall perform, at the Contractor's expense, the work required to substantiate the design, including testing of strength specimens. Complete concrete design data shall be submitted to the Engineer or designated representative for approval. The mix design will be valid for a period of one (1) year provided that there are no changes to the component materials.

When there are changes in aggregates or in type, brand or source of cement, supplementary cementing material or chemical admixtures, the mix shall be evaluated as a new mix design. A change in vendor does not necessarily constitute a change in materials or source. When only the brand or source of cement is changed and there is a prior record of satisfactory performance of the cement with the ingredients, the submittal of new trial batches may be waived by the Engineer or designated representative.

At the end of one (1) year, a previously approved mix may be resubmitted for approval if it can be shown that no substantial change in the component materials has occurred and that test results confirming the adequacy of the mix designs have been acquired during the previous year. The resubmittal analysis must be reviewed, signed and sealed by a registered Professional Engineer, licensed in the state of Texas. This resubmittal shall include a reanalysis of specific gravity, absorption, fineness modulus, sand equivalent, soundness, wear and unit weights of the aggregates. Provided that the fineness modulus did not deviate by more than 0.20 or that the re-proportioned total mixing water, aggregate and cement (or cement plus fly ash) are within 1, 2, and 3 percent, respectively, of pre-approved quantities, a one-year extension on the approval of the mix may be granted by the Engineer or designated representative. Updated cement, fly ash, and admixture certifications shall accompany the resubmittal.

Approved admixtures that are included in the prequalified concrete admixtures list maintained by TxDot's Construction Division may be used with all classes of concrete at the option of the Contractor provided that specific requirements of the governing concrete structure specification are met. Water reducing and retarding agents shall be required for hot weather, large mass, and continuous slab placements. Air entraining agents may be used in all mixes but must be used in the classes indicated on Table 5. Unless approved by the Engineer or designated representative, mix designs shall not exceed air contents for extreme exposure conditions as recommended by ACI 211.1 for the various aggregate grades.

#### **403S.7 Consistency and Quality of Concrete**

Concrete shall be workable, cohesive, possess satisfactory finishing qualities and of stiffest consistency that can be placed and vibrated into a homogeneous mass within slump requirements specified in Table 4 without the development of segregation or honeycombing. No concrete will be permitted with a slump in excess of the maximums



shown unless water-reducing admixtures have been previously approved. Concrete that exceeds the maximum acceptable placement slump at time of delivery will be rejected. Slump values shall be conducted in accordance with TXDOT Test Method TEX-415-A.

Consistency and quality of concrete should allow efficient placement and completion of finishing operations before initial set. Re-tempering (i.e. addition of water and reworking concrete after initial set) shall not be allowed. When field conditions are such that additional moisture is needed for final concrete surface finishing operation, the required water shall be applied to surface by fog spray only and shall be held to a minimum. Excessive bleeding shall be avoided and in no case will it be permissible to expedite finishing and drying by sprinkling the surface with cement powder.

Type of Construction	Slump <sup>1</sup> , inches (mm)	
	Maximum	Minimum
Cased Drilled Shafts	4 (100)	3 (75)
Reinforced Foundation Caissons and Footings	3 (75)	1 (25)
Reinforced Footings and Substructure Walls	3 (75)	1 (25)
Uncased Drilled Shafts	6 (150)	5 (125)
Thin-walled Sections; 9 inches (225 mm) or less	6 ½ (165)	4 (100)
Prestressed Concrete Members <sup>1</sup>	6 ½ (165)	4 (100)
Precast Drainage Structures	6 (150)	4 (100)
Wall Sections over 9 inches (225 mm)	5 (125)	3 (75)
Reinforced Building Slabs, Beams, Columns and Walls	4 (100)	1 (25)
Bridge Decks	4 (100)	2 (50)
Pavements, Fixed-form	6 ½ (165)	4 (100)
Pavements, Slip-form	3 (75)	1-½ (37.5)
Sidewalks, Driveways and Slabs on Ground	4 (100)	2 (50)
Curb & Gutter, Hand-vibrated	3 (75)	1 (25)
Curb & Gutter, Hand-tamped or spaded	4 (100)	2 (50)
Curb & Gutter, Slip-form/extrusion machine	2 (50)	½ (12.5)
Heavy Mass Construction	2 (50)	1 (25)
High Strength Concrete	4 (100)	3 (75)
Riprap and Other Miscellaneous Concrete	6 (150)	1 (25)
Under Water or Seal Concrete	8 ½ (213)	6 (150)

- Slump values when a high range water reducer (HRWR) is not used.
- When a high range water reducer (HRWR) is used, maximum acceptable placement slump will be 9 in (225 mm)

During progress of the work, the Engineer or designated representative shall cast test cylinders as a check on compressive strength of concrete actually placed. The Engineer or designated representative may also perform slump tests, entrained air tests and temperature checks to ensure compliance with specifications.

Proportioning of all material components shall be checked prior to discharging. Excluding mortar material for pre-coating of the mixer drum [see section 403S.8.B and adjustment for moisture content of admixtures and aggregates, material components shall fall within the range of + 1% for water, + 2% for aggregates, + 3% for cement, +2% for fly ash and within manufacturer recommended dosage rates for admixtures except that air entrainment shall be within + 1-1/2 percentage points of the mix design requirements.

Unless otherwise specified or indicated on the drawings, concrete mix temperature shall not exceed 90°F (32oC) except in mixes with high range water reducers where a maximum mix temperature of 100°F (38oC) will be allowed. Cooling an otherwise acceptable mix by addition of water or ice during agitation will not be allowed.

Test cylinders will be required for small placements such as manholes, inlets, culverts, wing walls, etc. The Engineer or designated representative may vary the number of tests to a minimum of 1 for each 25 cubic yards (1 for each 19 cubic meters) placed over a several day period.

Test cylinders shall be required for each monolithic placement of bridge decks or superstructures, top slabs of direct traffic culverts, cased drilled shafts, structural beams and as otherwise directed by Engineer or designated representative for design strength confirmation or early form removal. Test cylinders made for early form removal or for consideration of use of structure will be at Contractor's expense, except when required by Engineer or designated representative.

A strength test shall be defined as the average breaking strength of 2 cylinders. A minimum of four test cylinders shall be prepared; two each to be tested at 7 and 28 days. Specimens will be tested conforming to TXDOT Test Method TEX-418-A. If required strength or consistency of class of concrete being produced cannot be secured with minimum cementitious material specified or without exceeding maximum water/cementitious material ratio, Contractor will be required to furnish different aggregates, use a water reducing agent, an air entraining agent or increase the cement content in order to provide concrete meeting these specifications.

Slump tests will be performed in accordance with TxDOT Test Method Tex-415-A. Entrained air tests will be performed in accordance with TxDOT Test Method Tex-416-A.

Test specimens shall be cured using the same methods and under the same conditions as the concrete represented. Design strength cylinders shall be cured conforming to TXDOT Bulletin C-11 (and supplements thereto).

When control of concrete quality is by 28-day compressive tests, job control testing will be by 7-day compressive strength tests. The minimum strength requirement for seven (7) day test will be 70 percent of the specified minimum 28-day compressive strength. If the required 7-day strength is not secured with the quantity of cement specified in Table 4, changes in the mix design shall be made and resubmitted for approval. For an occasional failure of the seven-day compressive test, the concrete may be tested at 28 days for final evaluation.

Class	Cement Sks Per CY	Minimum Strength, psi (MPa)		Maximum W/C Ratio <sup>1</sup>	Coarse Aggr. Grade 2,3,4	Air Entrain.
		28 Days	7 Days			
A	5.0 (280 kg/m <sup>3</sup> )	3000 (20.6)	2100 (14.5)	0.6	1,2,3,4, 8	Yes
B	4.0 (225 kg/m <sup>3</sup> )	2000 (13.8)	1400 (9.7)	0.6	2,3,4,5,6,7	No
C5	6.0 (335 kg/m <sup>3</sup> )	3600(24.8)	2520 (17.4)	0.45	1,2,3,4,5,6	Yes
D	4.5 (252 kg/m <sup>3</sup> )	2500 (17.2)	1750 (12.1)	0.6	2,3,4,5,6,7	No
H5	6.0 (335 kg/m <sup>3</sup> )	As indicated	As Indicated	0.45	3,4,5,6	Yes
I	5.5 (308 kg/m <sup>3</sup> )	3500 (24.1)	2450 (16.9)	0.45	2,3,4,5	Yes
J	<del>2.0 (112 kg/m<sup>3</sup>)</del>	<del>800 (5.5)</del>	<del>560 (3.9)</del>	N/A	<del>2,3,4,5</del>	<del>No</del>
S5	6.0 (335 kg/m <sup>3</sup> )	4000 (27.6)	2800 (19.3)	0.45	2,3,4,5	Yes

Notes:

1. Maximum water-cement or water-cementitious ratio by weight
2. Unless otherwise allowed, Grade 1 coarse aggregate shall only be used in massive foundations with 4-in (100-mm) minimum clear spacing between reinforcing steel bars.
3. Grade 1 coarse aggregate grading shall not be used in drilled shafts.
4. Unless otherwise allowed, Grade 8 coarse aggregate shall be used in extruded curbs.
5. Structural concrete classes.
6. When Type II cement is used in Class C, S or A concrete, the 7-day compressive strength requirement will be 2310 psi (15.9 MPa) for Class C, 2570 psi (17.7 MPa) for Class S and 1925 psi (13.3 MPa) for Class A minimum.

Number Of Tests <sup>2,3</sup>	Standard Deviation, psi (MPa)				
	300 (2.06 )	400 (2.75 )	500 (3.44 )	600 (4.13)	700 (4.82 )
15	470 (3.24 )	620 (4.27)	850 (5.85)	1,120	1,390

				(7.71)	(9.57)
20	430 (2.96 )	580 (3.99)	760 (5.23)	1,010 (6.95)	1,260 (8.67)
30 or more	400 (2.75 )	530 (3.65)	670 (4.61)	900 (6.20)	1,130 (7.78)

Notes:

1. When designing the mix, add the tabulated amounts to the minimum design strength in Table 5. Maximum water-cement or water-cementitious ratio by weight
2. Number of tests of a concrete mixture used to estimate the standard deviation of a concrete production facility. Test of another mix within 1,000 psi (6.88 MPa) of the specified strength may be used.
3. If less than 15 prior tests are available, the overdesign should be 1,000 psi (6.88 MPa) for specified strength less than 3,000 psi (20.65 MPa), 1,200 psi (8.26 MPa) for specified strengths from 3,000 to 5,000 psi (20.65 to 34.42 MPa) and 1,400 psi (9.64 MPa) for specified strengths greater than 5,000 psi (34.42 MPa).

\* See Modifications for additional information

Class	General Usage
A	Inlets, manholes, curb, gutter, curb & gutter, concrete retards, sidewalks, <del>driveways</del> , backup walls and anchors
B	Riprap, small roadside signs and anchors
C5	Drilled shafts, bridge substructure, bridge railing, culverts except top slab of direct traffic culverts, headwalls, wing walls, approach slabs, and cast-in-place concrete traffic barrier
D	Riprap
H5	Prestressed concrete beams, boxes, piling and precast concrete traffic barrier
J	<del>Utility trench repair</del>
S5	Bridge slabs and top slabs of direct traffic culverts

Nominal Maximum Aggregate Size In (mm)	% Air Entrainment	
	Moderate Exposure	Severe Exposure
3/8 (9.5)- Grades 7 & 8	6	7-1/2
1/2 (12.5)- Grades 6	5-1/2	7
3/4 (19)- Grades 5	5	6
1 (25)- Grades 4	4-1/2	6
1-1/2 (37.5)- Grades 2 & 3	4-1/2	5-1/2
2 (50)- Grades 2	4	5

1. For specified concrete strengths above 5,000 psi (34.42 MPa) a reduction of 1 percentage point is allowed.

### 403S.8 Mix Design Options

For the structural concretes identified in Table 5 (Classes C, H and S) and any other class of concrete designed using more than 520 lbs. of cementitious material per cubic yard (310 kgs per cubic meter), one of the mix design options presented below shall be used.

For the non-structural concretes identified in Table 5 (Classes A, B, D and I) and any other class of concrete designed using less than 520 lbs. of cementitious material per cubic yard (310 kgs per cubic meter), one of the mix design options presented below will be used, except that Class C fly ash may be used instead of Class F fly ash for Options 1, 3 and 4 unless a sulfate-resistant concrete is required.

- A. Option 1: Twenty (20) to thirty-five (35) percent of the cement may be replaced with Class F fly ash.
- B. Option 2: Thirty-five (35) to fifty (50) percent of the cement may be replaced with ground granulated blast-furnace slag.
- C. Option 3: Thirty-five (35) to fifty (50) percent of the cement may be replaced with a combination of Class F fly ash, ground granulated blast-furnace slag or silica fume. The combination may not include more than thirty-five (35) percent fly ash and no more than ten (10) percent silica fume.
- D. Option 4: Type IP or Type IS will be used and up to ten (10) percent of the cement may be replaced with Class F fly ash, ground granulated blast-furnace slag or silica fume.
- E. Option 5: Thirty-five (35) to fifty (50) percent of the cement may be replaced with a combination of Class C fly ash and at least six (6) percent of silica fume, ultra fine fly ash or metakaolin. The combination may not include more than thirty-five (35) percent fly ash and no more than ten (10) percent silica fume.
- F. Option 6: A lithium nitrate admixture will be added at a minimum dosage of 0.55 gal. Of thirty (30) percent lithium nitrate solution per pound of alkalis present in the hydraulic cement.
- G. Option 7: When hydraulic cement only is used in the design, the total alkali contribution from the cement in the concrete does not exceed 4.0 lbs. Per cubic yard, when calculated as follows:

$$\text{alkali (lbs. per CY)} = .01 (\text{lbs cement/CY}) (\% \text{ Na}_2\text{O equivalent in cement})$$

where (% Na<sub>2</sub>O equivalent in cement) is assumed to be the maximum cement alkali content reported on the cement mill certificate.

- H. Option 8: When there are deviations from Options 1 through 7, the following shall be performed:
1. Conduct tests on both coarse and fine aggregate separately in accordance with ASTM C-1260, using 440 g of the proposed cementitious in the same proportions of hydraulic cement to supplementary cementing material to be used in the mix.
  2. Prior to use of the mix, a certified test report signed and sealed by a Professional Engineer, licensed in the state of Texas shall be submitted that demonstrates that ASTM C 1260 test results for each aggregate do not exceed 0.10 percent expansion.

#### **403S.9 Mixing and Mixing Equipment**

All equipment, tools and machinery used for hauling materials and performing any part of the work shall be maintained in such condition to insure completion of the work without excessive delays for repairs and replacement. Mixing shall be done in a mixer of approved type and size that will produce uniform distribution of material throughout the mass and shall be capable of producing concrete meeting requirements of ASTM C 94, Ready-mixed Concrete and these specifications. Mixing equipment shall be capable of producing sufficient concrete to provide required quantities. Entire contents of the drum shall be discharged before any materials are placed therein for a succeeding batch. Improperly mixed concrete shall not be placed in a structure. For all mixers an adequate water supply and an accurate method of measuring the water shall be provided.

The mixer may be batched by either volumetric or weight sensing equipment and shall be equipped with a suitable timing device that will lock the discharging mechanism and signal when specified time of mixing has elapsed.

##### **A. Proportioning and Mixing Equipment**

For all miscellaneous concrete placements, a mobile, continuous, volumetric mixer or a volumetric or weight batch mixer of the rotating paddle type may be used.

When approved by Engineer or designated representative in writing or when specified for use in other items, these mixers may be used for other types of concrete construction, including structural concrete, if the number of mixers furnished will supply the amount of concrete required for the particular operation in question.

These mixers shall be designed to receive all the concrete ingredients, including admixtures, required by the mix design in a continuous uniform rate and mix them to the required consistency before discharging.

For continuous volumetric mixers, the materials delivered during a revolution of the driving mechanism or in a selected interval, will be considered a batch and the proportion of each ingredient will be calculated in the same manner as for a batch type plant.

Mixing time shall conform to recommendations of manufacturer of mixer unless otherwise directed by Engineer or designated representative.

**B. Ready-mixed Concrete**

Use of ready-mixed concrete will be permitted provided the batching plant and mixer trucks meet quality requirements specified herein. When ready-mixed concrete is used, additional mortar (1 sack cement, 3 parts sand and sufficient water) shall be added to each batch to coat the mixer drum. Ready-mixed concrete, batching plant and mixer truck operation shall include the following:

1. A ticket system will be used that includes a copy for the Inspector. Ticket will have machine stamped time/date of concrete batch, a mix design designation, weight of cement, fly ash, sand and aggregates; exact nomenclature and written quantities of admixtures and water. Any item missing or incomplete on ticket may be cause for rejection of concrete.
2. Sufficient trucks will be available to support continuous placements. The Contractor will satisfy the Engineer or designated representative that adequate standby trucks are available to support monolithic concrete placement requirements.
3. A portion of mixing water required by the mix design to produce the specified slump may be withheld and added at the job site, but only with permission of the Engineer or designated representative and under the Inspector's observation. When water is added under these conditions, the concrete batch will be thoroughly mixed before any slump or strength samples are taken. Additional cement shall not be added at the job site to otherwise unacceptable mixes.
4. A metal plate(s) shall be attached in a prominent place on each truck mixer plainly showing the various uses for which it was designed. The data shall include the drum's speed of rotation for mixing and for agitating and the capacity for complete mixing and/or agitating only. A copy of the manufacturer's design, showing dimensions of blades, shall be available for inspection at the plant at all times. Accumulations of hardened concrete shall be removed to the satisfaction of the Engineer or designated representative.
5. The loading of the transit mixers shall not exceed capacity as shown on the manufacturer's plate attached to the mixer or 63 percent of the drum volume, whichever is the lesser volume. The loading of transit mixers to the extent of causing spill-out enroute to delivery will not be acceptable. Consistent spillage will be cause for disqualification of a supplier.
6. Excess concrete remaining in the drum after delivery and wash water after delivery shall not be dumped on the project site unless approval of the dump location is first secured from the Engineer or designated representative.

**C. Volumetric Batching \* See Modifications for additional information**

~~Use of volumetric batched concrete will be permitted provided the batching and continuous mixing operations conform to ASTM C 685, "Concrete Made By Volumetric Batching and Continuous Mixing". This type concrete shall be made from materials continuously batched by volume, mixed in a continuous mixer and delivered to the site in a freshly mixed and unhardened state. Tests and criteria for batching accuracy and mixing efficiency shall be as specified in ASTM C 685.~~

~~A ticket system will be used that includes a copy for the Inspector. The ticket will have machine stamped time/date of concrete batch, a mix design designation, weight of cement, fly ash, sand and aggregates; exact nomenclature and written quantities of admixtures and water. Any item missing or incomplete on ticket may be cause for rejection of concrete.~~

~~Each batching or mixing unit, or both, shall carry in a prominent place a metal plate or plates on which are plainly marked the gross volume of the unit in terms of mixed concrete, discharge speed and the weight calibrated constant of the machine in terms of a revolution counter or other output indicator. The mixer shall produce a thoroughly mixed and uniform concrete.~~

~~The batcher mixer unit shall contain in separate compartments all the necessary ingredients needed for the manufacture of concrete. The unit shall be equipped with calibrated proportioning devices to vary the mix proportions and it shall produce concrete as required by the Work and ASTM C 685.~~

#### D. Truck-mixed Concrete

The concrete shall be mixed in a truck mixer from 70 to 100 revolutions at the mixing speed designated by the manufacturer that will produce a uniform concrete mix. The concrete shall be delivered to the project in a thoroughly mixed and uniform mass and shall be discharged with a satisfactory degree of uniformity. Additional mixing at the job site, at the mixing speed designated by the manufacturer, may be allowed by the Engineer or designated representative as long as the concrete is discharged before the drum has revolved a total of 300 revolutions after the introduction of the mixing water to the cement and the aggregates.

Re-tempering or adding concrete chemical admixtures is only permitted at the job site when concrete is delivered in a truck mixer. Water shall not be added after introduction of mixing water at the batch plant except on arrival at the job site with approval of the Engineer or designated representative, in order to adjust the slump of the concrete. When this water is added, the mix design water-cementitious-material ratio shall not be exceeded. The drum or blades shall be turned at least 30 additional revolutions at mixing speed to ensure thorough and uniform mixing of the concrete. Water or chemical admixtures shall not be added to the batch after any concrete has been discharged.

When the concrete contains silica fume, mixing times and batching operations shall be adjusted as necessary to ensure that the material is completely and uniformly dispersed in the mix. The dispersion of the silica fume within the mix shall be verified in trial batches.

#### E. Hand-mixed Concrete



Hand mixing of concrete may be permitted for small placements or in case of an emergency and then only on authorization of the Engineer or designated representative. Hand-mixed batches shall not exceed a 4 cubic foot (0.113 cubic meters) batch in volume. Material volume ratios shall not be leaner than 1 part cement, 2 parts large aggregate, 1 part fine aggregate and enough water to produce a consistent mix with a slump not to exceed 4 inches (100 mm). Admixtures shall not be used unless specifically approved by the Engineer or designated representative.

#### **403S.10 Excavation, Placing of Concrete, Finishing, Curing and Backfill**

Excavation, placing of concrete, finishing, curing and backfill shall conform to Standard Specification Item No. 401S, "Structural Excavation and Backfill", Standard Specification Item No. 410S, "Concrete Structures" and Standard Specification Item No. 411S, "Surface Finishes for Concrete".

#### **403S.11 Measurement**

Where measurement of concrete for a structure is not provided by another governing pay item, measurement shall be made under this specification in accordance with the following.

The quantities of concrete of the various classifications which constitute the completed and accepted structure or structures in place will be measured by the cubic yard (cubic meters: 1 cubic meter is equal to 1.308 cubic yards), each, square yard (square meter: 1 square yard equals 0.836 square meters) or linear foot as indicated in the Contract Documents. Measurement will be as follows:

##### **A. General**

1. Measurement based on dimensions shall be for the completed structure as measured in place. However, field-measured dimensions shall not exceed those indicated on the drawings or as may have been directed by the Engineer or designated representative in writing.
2. No deductions shall be made for chamfers less than 2 inches (50 mm) in depth, embedded portions of structural steel, reinforcing steel, nuts, bolts, conduits less than 5 inches (125 mm) in diameter, pre/post tensioning tendons, keys, water stops, weep holes and expansion joints 2 inches (50 mm) or less in width.
3. No measurement shall be made for concrete keys between adjoining beams or prestressed concrete planks.
4. No measurement shall be made for fill concrete between the ends or adjoining prestressed concrete planks/box beams at bent caps or between the ends of prestressed concrete planks/box beams and abutment end walls.

5. No measurement shall be made for inlet and junction box invert concrete.
  6. No measurement shall be made for any additional concrete required above the normal slab thickness for camber or crown.
- B. Plan Quantity. For those items measured for plan quantity payment, adequate calculations have been made. If no adjustment is required by Article 403S.12, additional measurements or calculations will not be required or made.
- C. Measured in Place. For those items not measured for Plan Quantity payment, measurement will be made in place, subject to the requirements of Article 403S.10.A.1 above.

#### **403S.12 Payment**

The work performed and materials furnished as prescribed by this item and measured in accordance with the applicable provisions of "Measurement" above will be paid for as follows.

The quantity to be paid for will be that quantity indicated in the contract documents and/or shown on the drawings, regardless of errors in calculations, except as may be modified by the following.

Plan Quantities will be adjusted:

- A. When a complete structure element has been erroneously included or omitted from the drawings, the quantity shown on the drawings for that element will be added to or deducted from the plan quantity and included for payment. A complete structure element will be the smallest portion of a total structure for which a quantity is included on the drawings. Quantities revised in this manner will not be subject to the provisions of the "General Conditions", Article 11.
- B. When the plan quantity for a complete structure element is in error by 5 percent or more, a recalculation will be made and the corrected quantity included for payment. Quantities revised in this manner will not be subject to the provisions of the "General Conditions", Article 11
- C. When quantities are revised by a change in design, the "plan quantity" will be increased or decreased by the amount involved in the design change. Quantities revised in this manner will be subject to the provisions of the "General Conditions", Article 11.

The party to the contract requesting the adjustment shall present to the other, a copy of the description and location, together with calculations of the quantity for the structure element involved. When this quantity is certified correct by the Engineer or designated representative, it will become the revised plan quantity.

Payment for increased or decreased costs due to a change in design on those items measured as "Cubic Yard", "Each", "Square Foot", "Square Yard" or "Linear

Foot" will be determined by Change Order. Quantities revised in this manner will be subject to the provisions of the "General Conditions", Article 11.

The unit prices bid for the various classes of concrete shown shall include full compensation for furnishing, hauling, and mixing all concrete material; placing, finishing and curing all concrete; all grouting, pointing and finishing; furnishing and placing drains; furnishing and placing metal flashing strips; furnishing and placing expansion joint material required by this item; and for all forms and false work, labor, tools, equipment and incidentals necessary to complete the work.

Pay Item No. 403S-CY: (Structure or Structural Component) - Per Cubic Yard.

Pay Item No. 403S-EA: (Structure or Structural Component) - Per Each.

Pay Item No. 403S-SY: (Structure or Structural Component) - Per Square Yard.

Pay Item No. 403S-LF: (Structure or Structural Component) - Per Lineal Foot.

**End**

<b>SPECIFIC CROSS REFERENCE MATERIALS</b>
<b>Standard Specification Item 403S, "Concrete For Structures"</b>

City of Austin Standard Specification Items

<u>Designation</u>	<u>Description</u>
Item No. 401S	Structural Excavation and Backfill
Item No. 410S	Concrete Structures
Item No. 411S	Surface Finishes for Concrete

Texas Department of Transportation: Departmental Material Specifications

<u>Designation</u>	<u>Description</u>
DMS-4640	Chemical Admixtures for Concrete
DMS-4610	Fly Ash
DMS-4620	Ground Granulated Blast-Furnace Slag
DMS-4630	Silica Fume
DMS-4635	Metakaolin

American Association of State Highway & Transportation Officials,  
AASHTO Standard Method of Test for

<u>Designation</u>	<u>Description</u>
Method T 26	Quality of Water to be Used in Concrete

American Concrete Institute, ACI

<u>Designation</u>	<u>Description</u>
ACI 211.1	Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete

American Society for Testing and Materials, ASTM

<u>Designation</u>	<u>Description</u>
ASTM C 94	Specification For Ready-Mixed Concrete
ASTM C 150	Specification For Portland Cement
ASTM C 685	Concrete Made By Volumetric Batching and Continuous Mixing
ASTM C-1260	Standard Test Method for Potential Alkali Reactivity of Aggregates
ASTM D-512	Test Methods for Chloride Ion in Water
ASTM D-516	Test Methods for Sulfate Ion in Water
ASTM D-4191	Test Method for Sodium in Water by Atomic Absorption
ASTM D-4192	Test Method for Potassium Water by Atomic Absorption

Texas Department of Transportation: Manual of Testing Procedures

<u>Designation</u>	<u>Description</u>
TEX-203-F	Sand Equivalent Test
TEX-401-A	Sieve Analysis of Fine and Coarse Aggregate
TEX-406-A	Mineral Finer than 75 $\mu\text{m}$ (No. 200) Sieve in Mineral Aggregates (Decantation Test for Concrete Aggregates)
TEX-408-A	Organic Impurities in Fine Aggregate for Concrete
TEX-410-A	Abrasion of Coarse Aggregate Using The Los Angeles Machine

TEX-411-A	Soundness of Aggregate by Use of Sodium Sulfate or Magnesium Sulfate
TEX-413-A	Determination of Deleterious Materials in Mineral Aggregate
TEX-415-A	Slump of Portland Cement Concrete
TEX-416-A	Air Content of Freshly-Mixed Concrete by the Pressure Method
TEX-418-A	Compressive Strength of Cylindrical Concrete Specimens
TEX-612-J	Acid Insoluble Residue

<b>SPECIFIC CROSS REFERENCE MATERIALS (Continued)</b>
<b>Standard Specification Item 403S, "Concrete For Structures"</b>

Texas Department of Transportation: Publications

<u>Designation</u>	<u>Description</u>
Bulletin C-11	Construction Bulletin

<b>RELATED CROSS REFERENCE MATERIALS</b>
<b>Standard Specification Item 403S, "Concrete For Structures"</b>

Texas Department of Transportation: Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges

<u>Designation</u>	<u>Description</u>
Item 360	Concrete Pavement
Item 420	Concrete Structures
Item 421	Hydraulic Cement Concrete
Item 427	Surface Finishes for Concrete
Item 431	Pneumatically Placed Concrete

Item 520                      Weighing and Measuring Equipment

Texas Department of Transportation: Departmental Material Specifications

<u>Designation</u>	<u>Description</u>
DMS-4650	Hydraulic Cement Concrete Curing Materials and Evaporation Retardants”
DMS-6100	Epoxy and Adhesives
DMS 8900	Fly Ash