

**Item No. 410S
Concrete Structures**

410S.1 Description

This item shall govern the construction of all types of structures involving the use of structural concrete, except where the requirements are waived or revised by other governing specifications.

All concrete structures shall be constructed in accordance with the design requirements and details indicated on the drawings, in conformity with the pertinent provisions of the items contracted for, the incidental items referred to and in conformity with the requirements herein.

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

410S.2 Submittals

The submittal requirements of this specification item may include:

Appropriate mix designs for class of concrete for each type of structure or unit;

Appropriate mortar and grout mix designs;

Product name, description, technical information and supplier of any acrylic-polymer latex admixture;

Type, supplier and certified test results for expansion joint materials;

Type of waterstop and confirmation that the product conforms to TxDOT DMS-6160;

Type and manufacturer of proposed evaporation retardant and confirmation that it meets the requirements of test results for TxDOT DMS-4650;

Type and manufacturer of proposed chemical admixtures and confirmation that it meets the requirements of test results for TxDOT DMS-4640;

Type and manufacturer of proposed curing admixtures and confirmation that it meets the requirements of test results for TxDOT DMS-4640;

Type and manufacturer of proposed chemical admixtures and confirmation that it meets the requirements of test results for TxDOT DMS-4640;

Type and manufacturer of proposed epoxy and/or adhesives and confirmation that it meets the requirements of test results for TxDOT DMS-6100;

Reinforcing steel shall conform to Standard Specification Item No. 406S, "Reinforcing Steel".

Contractors formwork plan for placing and consolidating concrete around wall penetrations and at locations designated as having congested reinforcing steel.

410S.3 Materials

A. Concrete

Concrete shall conform to Item No. 403S, "Concrete for Structures".

The class of concrete for each type of structure or unit shall be as indicated on the drawings or by pertinent governing specifications.

B. Grout or Mortar

When required or shown on the drawings, mortar and grout consisting of 1 part hydraulic cement and 2 parts sand with sufficient water to provide the desired consistency shall be provided. Mortar shall be provided with a consistency that can be handled easily and spread by a trowel. Grout shall be provided with a consistency that will flow into and completely fill all voids.

C. Latex

When required an acrylic-polymer latex admixture (acrylic resin emulsion in accordance with TxDOT DMS-4640, "Chemical Admixtures for Concrete") suitable for producing polymer-modified concrete or mortar shall be provided. The latex shall not be allowed to freeze.

The following information shall be submitted for latex:

- Name and information of company contact personnel,
- Product name and polymer description, and
- The latex shall meet the following requirements.

Property	Value
Total Solids, minimum, percent	47
PH	9.0 to 11.0
Brookfield viscosity (# 1 spindle @ 10 rpm), mPas, maximum	60
Butadiene Content, percent	30 to 40
Freeze-thaw stability, 2 cycles. maximum	0.1

Specification targets and production tolerances shall also be provided for the following properties.

1. viscosity (including test method and temperature reference),
2. percent solids,
3. pH,
4. specific gravity, and
5. styrene/butadiene ratio.

D. Reinforcing Steel

Reinforcing steel shall conform to Standard Specification Item No. 406S, "Reinforcing Steel".

E. Expansion Joint Material

The expansion joint material shall conform to the requirements of TxDOT DMS-6310, "Joint Materials and Fillers".

1. Preformed Fiber Sheets

Unless otherwise indicated on the drawings preformed bituminous fiber material shall be provided. The preformed fiber material shall conform to the dimensions indicated on the drawings. Preformed fiber sheets shall meet the requirements of ASTM D-1751, "Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types). The requirements related to bitumen content, density and water absorption shall not apply to nonbituminous materials.

2. Joint Sealing Material

Unless otherwise indicated on the drawings a Class 4, 5 or 7 low-modulus silicone sealant shall be provided that conforms to the requirements of TxDOT DMS-6310, "Joint Sealants and Fillers".

3. Timber Boards

Timber boards shall be made from redwood or cypress and must be free from sapwood, knots, clustered bird's eye, checks and splits. When oven dried at 230°F (110°C) to a constant weight (mass), the density of the board shall be between 20 and 35 lbs. Per cubic foot (between 320 and 560 kgs per cubic meter)

4. Asphalt Board

Asphalt Board shall conform to the dimensions indicated on the drawings and shall meet the description, general requirements and distortion testing of ASTM D-994, "Preformed Expansion Joint Filler for Concrete (bituminous Type)".

5. Rebonded Neoprene Filler Sheet

Rebonded neoprene filler shall consist of ground closed cell neoprene particles, rebonded and molded into sheets of uniform thickness of the dimensions indicated on the drawings. These sheets shall meet the requirements of ASTM D-1752, Type I.

The manufacturer shall furnish the Engineer or designated representative with certified test results as to the compliance with the above requirements.

F. Waterstop

Unless otherwise indicated on the drawings, rubber waterstops or Polyvinyl Chloride (PVC) waterstops that conform to TxDOT DMS-6160, "Waterstops, Nylon Reinforced Neoprene Sheet, and Elastomeric Pads" shall be provided.

G. Evaporation Retardants

Evaporation retardants shall conform to the requirements of TxDOT DMS-4650, "Hydraulic Cement Concrete Curing Materials and Evaporation Retardants". The evaporation retardant must be a commercially available monomolecular film compound. The evaporation retardant shall have no adverse effect on the cement hydration process or the concrete and shall reduce surface moisture evaporation from the concrete when performing concrete operations in direct sun, wind, high temperatures, or low relative humidity. The producer of the evaporation retardant shall certify that it meets these specified requirements.

H. Curing Materials

1. Liquid Membrane Forming compounds

Liquid Membrane Forming compounds shall conform to the requirements of TxDOT DMS-4650, "Hydraulic Cement Concrete Curing Materials and Evaporation Retardants". The compound shall be applied to damp concrete as a fine mist through atomizing nozzles at a wet film thickness of 8 to 9 mils (200 to 230 μm). The liquid membrane-forming compound must not react deleteriously with concrete or its components. It must produce a firm, continuous, uniform moisture-impermeable film that is free of pinholes, cracks, or other film defects. It must also exhibit satisfactory adhesion.

The consistency must be such that the compound can be applied satisfactorily by conventional or airless spray at atmospheric and material temperatures above 40°F (5°C) without thinning. When applied at the manufacturer's recommended thickness, not less than 8 mils (200 μm) wet, to vertical surfaces of damp concrete, the compound must not run off or appreciably sag. The liquid membrane-forming compound must not disintegrate, check, peel, or crack during the required curing period. It must not peel or pick up under traffic, and must disappear from the surface of the cured concrete by gradual disintegration.

2. Cotton Mats

Cotton mats shall consist of a filling material of cotton "bat" or "bats" [at least 12 oz. Per square yard (400 grams per square meter)] completely covered with unsized cloth [at least 6 oz. Per square yard (200 grams per square meter)] stitched longitudinally with continuous parallel rows of stitching spaced at less than 4 in. (100 mm), or tuft both longitudinally and transversely at intervals less than 3 in. (75 mm).

The cotton mats shall be free from tears and in good general condition. A flap at least 6 in. (150 mm) wide with two (2) thicknesses of the covering that extends along one side of the mat shall be provided.

3. Polyethylene Sheeting

The polyethylene sheeting shall be at least 4 mils thick (0.1 mm) and free from visible defects. Clear or opaque white sheeting shall be provided when the ambient temperature during curing exceeds 60°F (15°C) or when applicable to control temperature during mass pours.

4. Burlap-Polyethylene Mats

The burlap-polyethylene mats shall be made from burlap impregnated on 1 side with a film of opaque white-pigmented polyethylene, free from visible defects. The laminated mats shall have at least 1 layer of an impervious material such as polyethylene, vinyl plastic, or other acceptable material (either as a solid sheet or impregnated into another fabric) and shall be free of visible defects.

I. Chemical Admixtures

Chemical admixtures including water reducing, plasticizers and air entrainment shall conform to TxDOT DMS-4640, "Chemical Admixtures for Concrete" Calcium chloride shall not be used. Admixtures shall be included in the prequalified concrete admixtures list maintained by TxDOT's Construction Division.

J. City of Austin Survey Monuments

The Public Works Department may furnish permanent survey monuments to be cast in concrete as indicated on the drawings or as directed by the Engineer or designated representative.

K. Epoxy

Unless indicated otherwise on the drawings, epoxy materials shall conform to TxDOT DMS-6100, "Epoxy and Adhesives".

410S.4 General Requirements

Before starting work, the Contractor shall inform the Engineer or designated representative fully of the construction methods the Contractor proposes to use, the adequacy of which shall be subject to the review by the Engineer or designated representative. Drawings for forms and falsework for piers and superstructure spans over 20 feet (6 meters) long, bracing systems for girders when the overhang exceeds 3 ft. 6 in. (1 meter) and for all bridge widening details shall be submitted to the Engineer or designated representative for review, if requested. Similar drawings shall be submitted for other units of the structure, if requested by the Engineer or designated representative. The drawings shall be prepared on standard 22 inch by 36-inch (550mm by 900 mm) sheets and shall show all essential details of the proposed forms, falsework and bracing to permit a structural analysis. Four sets of such drawings will be required.

Concurrence on the part of the Engineer or designated representative in any proposed construction methods, approval of equipment or of form and falsework drawings does not relieve the Contractor of the responsibility for the safety or correctness of the Contractor's methods, adequacy of equipment or from carrying out the work in full accordance with the contract.

Unless otherwise indicated on the drawings, the requirements in the succeeding paragraphs shall govern the time sequence in which construction operations may be carried on and for the opening of completed structures to traffic:

Superstructure members, forms, falsework or erection equipment shall not be placed on the substructure before the concrete therein has attained a 3000 psi (20.7 MPa) compressive strength.

Storage of materials on completed portions of a structure will not be permitted until all curing requirements for those particular portions have been met.

No forms shall be erected on concrete footings supported by piling or drilled shafts until the concrete therein has attained a minimum compressive strength of 2500 psi (17.2 MPa). Such work may begin on spread footings after the therein has aged at least 2 curing days. Concrete may be placed as soon as the forms and reinforcing steel are approved by the Engineer or designated representative.

The support of tie beam and/or forms by falsework placed on previously placed tie beams is permissible provided such beams have attained 3000 psi (20.7 MPa) compressive strength, curing requirements are completed and the beams are properly supported to eliminate stresses not provided for in the design.

Bridges and direct traffic culverts shall not be opened to construction traffic or to the traveling public until authorized by the Engineer or designated representative in accordance with the following:

Authorization may be given after the last slab concrete has been in place at least 14 days for light construction traffic not to exceed a 3/4-ton (0.68 Mg) vehicle.

Authorization to place embankments to allow normal construction traffic and when necessary to the traveling public, may be given after the last slab concrete has been in place 30 days or when the minimum compressive strength (f_c') has reached the 28 day strength conforming to Item No. 403S, "Concrete for Structures" or as indicated on the drawings.

410S.5 Drains

Weep holes and roadway drains shall be installed and constructed as indicated on the drawings.

410S.6 Expansion Joints

Joints and devices shall be used to provide for expansion and contraction of concrete slabs and shall be constructed as indicated on the drawings.

The bearing area under the expansion ends of concrete slabs and slab and girder spans shall be given a steel trowel finish and finished to the exact grades required on the drawings. The material used to separate expansion surfaces shall be as indicated on the drawings and placed so that concrete or mortar cannot be subsequently worked around or under it. The bridging of concrete or mortar around expansion joint material in bearings and expansion joints shall be prevented.

Concrete adjacent to armor joints and finger joints shall be placed carefully to avoid defective anchorage and porous or honeycombed concrete in such areas.

All open joints and joints to be filled with expansion joint material shall be constructed using forms adaptable to loosening or early removal. To avoid expansion or contraction damage to the adjacent concrete, these forms shall be loosened as soon as possible after final concrete set to permit free movement of the span without requiring full form removal.

Prefomed fiber joint material or other material indicated shall be used in the vertical joints of the roadway slab, curb, median or sidewalk. The top 1-inch (25 mm) thereof shall be filled with joint sealing material, as specified herein. The sealer shall be installed in accordance with Standard Specification Item No. 413S, "Cleaning and/or Sealing Joints and Cracks (PC Concrete)" and the manufacturer's recommendations.

Prior to placing the sealing material, the vertical faces of the joint shall be cleaned of all laitance by sandblasting or by mechanical routing. Cracked or spalled edges shall be repaired. The joint shall be blown clean of all foreign material and sealed.

Where prefomed fiber joint material is used, it shall be anchored to the concrete on one side of the joint by light wire or nails to prevent the material from falling out.

Finished joints shall conform to the drawing details with the concrete sections completely separated by the specified opening or joint material.

Soon after form removal and where necessary after surface finishing, all projecting concrete shall be removed along exposed edges to secure full effectiveness of the expansion joints.

410S.7 Construction Joints

The joint formed by placing plastic concrete in direct contact with concrete that has attained its initial set shall be deemed a construction joint. The term monolithic placement shall be interpreted to mean that the manner and sequence of concrete placing shall not create construction joints.

Construction joints shall be of the type and at the locations indicated on the drawings. Additional joints will not be permitted without written authorization from the Engineer or designated representative and when authorized, shall have details equivalent to those indicated for joints in similar locations.

Unless otherwise provided, construction joints shall be square and normal to the forms. Bulkheads shall be provided in the forms for all joints, except when horizontal. All vertical construction joints shall be chamfered. All horizontal construction joints shall be routed or grooved.

Construction joints requiring the use of joint sealing material shall be as indicated on the drawings or as directed by the Engineer or designated representative. The material will be indicated on the drawings without reference to joint type.

A concrete placement terminating at a horizontal construction joint shall have the top surface roughened thoroughly as soon as practicable after initial set is attained. The surfaces at bulkheads shall be roughened as soon as the forms are removed.

The hardened concrete surface shall be thoroughly cleaned of all loose material, laitance, dirt or foreign matter and saturated with water so it is moist when placing fresh concrete against it. Remove all free water and moisten the surface before concrete or bonding grout is placed against it. Forms shall be drawn tight against the existing concrete and the joint surface flushed with grout just prior to placing the fresh concrete.

The joint surface shall be coated with bonding mortar, grout, epoxy or other material as indicated on the drawings or other items. A Type V epoxy shall be provided in accordance with TxDoT DMS-6100, "Epoxies and Adhesives" for bonding fresh concrete to hardened concrete. The epoxy shall be placed on a clean dry surface and the fresh concrete shall be placed while the epoxy is still tacky. Bonding mortar or grout shall be placed on a surface that is saturated surface dry and the concrete shall be placed before the bonding mortar or grout dries. Other bonding agents shall be placed in accordance with the manufacturer's recommendations.

410S.8 Foundation and Substructure

Excavation for foundations and substructure shall conform to Standard Specification Item No. 401S, "Structural Excavation and Backfill".

Concrete for foundation seals, unless otherwise indicated on the drawings, shall be Class C Concrete with a coarse aggregate grade of 2, 3, 4 or 5 and placed in accordance with the requirements herein. The top of the completed seal shall not vary from plan grade or the grade established by the Engineer or designated representative.

Where a concrete seal is indicated on the Drawings, the design will be based on the normal water elevation as indicated on the Drawings. If the foundation concrete can be placed in the dry at the time of construction, the seal will not be required. If additional seal is necessary for the conditions existing during the time of construction, its thickness shall be increased as deemed necessary by the Contractor and at the Contractor's expense. If the conditions existing at the time of construction require a seal for placing the foundation concrete in the dry and none is indicated on the Drawings, the Contractor shall place an adequate seal at the Contractor's expense.

The seal shall be allowed to set for at least 36 hours before the caisson or cofferdam is dewatered, after which the top of the seal shall be cleaned of all laitance or other soft material and all high spots exceeding the above limitation shall be cut off and removed.

410S.9 Falsework

The Contractor is totally responsible for all falsework. The Contractor shall design and construct it to safely carry the maximum anticipated loads and to provide the necessary rigidity. Details of falsework construction shall be subject to review by the Engineer or designated representative, but Engineer's review shall in no way relieve the Contractor of responsibility of the adequacy and safety of the falsework design.

All timber used in falsework centering shall be sound, in good condition and free from defects which will impair its strength. When wedges are used to adjust falsework to desired elevations, they shall be used in pairs to insure even bearing.

Sills or grillages shall be large enough to support the superimposed load without settlement and unless founded on solid rock, shale or other hard materials, precautions shall be taken to prevent yielding of the supporting material.

Falsework, which cannot be founded on a satisfactory spread footing, shall be placed on piling driven to a bearing capacity sufficient to support the superimposed load without settlement. The safe bearing capacity of piling shall be determined by test loads or by such other methods that may be required or acceptable to the Engineer or designated representative.

In general, each falsework bent shall be capped transversely by a member of proper size. A short cap section forming a T-head may be substituted to permit the removal of portions of the forms without disturbing the falsework. Caps shall be securely fastened to each pile or column in the bent and set at the proper elevation to produce, in conjunction with the use of approved wedges or jacks, permanent camber indicated on the Drawings, plus a construction camber covering allowance for deformation of the forms and falsework. The use of wedges to compensate for incorrectly cut bearing surfaces will not be permitted. Each falsework bent shall be securely braced to provide the stiffness required with the bracing securely fastened to each pile or column it crosses.

In setting falsework for arches, allowances shall be made for settlement of falsework, deflection of the arch and permanent camber. Provision shall be made by suitable wedges, sand jacks or other acceptable devices for the controlled lowering of falsework when the arch is swung. Falsework may be required to be placed on jacks to provide for settlement correction during concrete placement.

When the falsework is no longer required, it shall be removed. Falsework piling shall be pulled or cut off not less than 2 feet (0.6 meter) below finished ground level. Falsework and piling in a stream, lake or bay shall be completely removed to a point specified by the Engineer or designated representative to prevent any obstruction to the waterway.

410S.10 Forms

Forms for precast prestressed concrete members and for prestressed piling shall be constructed conforming to Item No. 425S, "Prestressed Concrete Structures".

A. General

Except where otherwise indicated on the drawings, forms may be of either timber or metal.

Forms for round columns exposed to view shall be of steel, except that other materials will be allowed with written permission of the Engineer or designated representative.

Forming plans shall be submitted for approval by the Engineer or designated representative. Forms shall be designed for the pressure exerted by a liquid weighing 150 pounds per cubic foot (2.4 Mega grams per cubic meter). The rate of placing the concrete shall be taken into consideration in determining the depth of the equivalent liquid. For job-fabricated forms an additional live load of 50 pounds per square foot (1.675 MPa) shall be allowed on horizontal surfaces. The maximum unit stresses shall not exceed 125 percent of the allowable stresses used by the Engineer or designated representative for the design of structures.

Formwork for wall and/or column pours equal or exceeding 8 feet (2.44 meters) shall be designed in accordance with ACI 347, "Guide to Formwork for Concrete" and sealed by a Registered Civil Engineer Licensed in the State of Texas, who is experienced in formwork design.

Commercially produced structural units used in formwork shall not exceed the manufacturer's maximum allowable working load for moment, shear or end reaction. The maximum working load shall include a live load of 35 pounds per square foot (1.175 MPa) of horizontal form surface and sufficient details and data shall be submitted for use in checking formwork details for approval.

Forms shall be practically mortar-tight, rigidly braced and strong enough to prevent bulging between supports and maintained to the proper line and grade during concrete placement. Forms shall be maintained in a manner that will prevent warping and shrinkage.

Deflections due to cast-in-place slab concrete and railing shown in the dead load deflection diagram shall be taken into account in the setting of slab forms.

All forms and footing areas shall be cleaned of any extraneous matter before placing concrete.

Permission to place concrete will not be given until all of such work is complete to the satisfaction of the Engineer or designated representative.

If, at any stage of the work, the forms show signs of bulging or sagging, the portion of the concrete causing such condition shall be removed immediately, if necessary and the forms shall be reset and securely braced against further movement.

B. Timber Forms

Lumber for forms shall be properly seasoned, of good quality and free from imperfections, which would affect its strength or impair the finished surface of the concrete. The lumber used for facing or sheathing shall be finished on at least 1 side and 2 edges and shall be sized to uniform thickness.

Form or form lumber that will be reused shall be maintained clean and in good condition. Lumber that is split, warped, bulged, or marred or that has defects that will produce inferior forms shall not be used but shall be removed from the work.

Form lining will be required for all formed surfaces, except for the inside of culvert barrels, inlets, manholes and box girders, the bottom of bridge decks between beams or girders, surfaces that are subsequently covered by backfill material or are completely enclosed and any surface formed by a single finished board. Lining will not be required when plywood forms are used.

Form lining shall be of an approved type such as masonite or plywood. Thin membrane sheeting such as polyethylene sheets shall not be used for form lining.

Forms may be constructed of plywood not less than $\frac{3}{4}$ inch (19 mm) in thickness, with no form lining required. The grain of the face plies on plywood forms shall be placed parallel to the span between the supporting studs or joists.

Plywood used for forming surfaces, which remain exposed, shall be equal to that specified as B-B Plyform Class I or Class II Exterior of the U.S. Department of Commerce Voluntary Product Standard, PS 1.

Studs and joists shall be spaced so that the facing form material remains in true alignment under the imposed loads.

Wales shall be spaced close enough to hold forms securely to the designated lines and scabbed at least 4 feet (1.22 meters) on each side of joints to provide continuity. A row of wales shall be placed near the bottom of each placement.

Facing material shall be placed with parallel and square joints and securely fastened to supporting studs.

Forms for surfaces receiving only an ordinary finish and exposed to view shall be placed with the form panels symmetrical, i.e., long dimensions set in the same direction. Horizontal joints shall be continuous.

Molding specified for chamfer strips or other uses shall be made of materials of a grade that will not split when nailed and which can be maintained to a true line without warping. Wood molding shall be mill cut and dressed on all faces. Unless indicated otherwise on the drawings, forms shall be filleted at all sharp corners and edges with triangular chamfer strips measuring $\frac{3}{4}$ inch (19 mm) on the sides.

Forms for railings and ornamental work shall be constructed to standards equivalent to first class millwork. All moldings, panel work and bevel strips shall be straight and true with neatly mitered joints designed so the finish work is true, sharp and clean cut. All forms shall be constructed to permit their removal without marring or damaging the concrete. The forms may be given a slight draft to permit ease of removal.

Metal form ties of an approved type or a satisfactory substitute shall be used to hold forms in place and shall be of a type that permits ease of removal of the metal as hereinafter specified.

All metal appliances used inside of forms for alignment purposes shall be removed to a depth of at least 1/2 inch (13 mm) from the concrete surface. They shall be made so the metal may be removed without undue chipping or spalling and when removed, shall leave a smooth opening in the concrete surface. Burning off of rods, bolts or ties will not be permitted.

Any wire ties used shall be cut back at least 1/2 inch (13 mm) from the face of the concrete and properly patched.

Devices holding metal ties in place shall be capable of developing the strength of the tie and adjustable to allow for proper alignment.

Metal and wooden spreaders, which are separate from the forms, shall be removed entirely as the concrete is being placed.

Adequate clean-out openings shall be provided for narrow walls and other locations where access to the bottom of the forms is not readily attainable.

Prior to placing concrete, the facing of all forms shall be treated with oil or other bond breaking coating of such composition that it will not discolor or otherwise injuriously affect the concrete surface. Care shall be exercised to prevent coating of the reinforcing steel.

C. Metal Forms

The foregoing requirements for timber forms as regards design, mortar-tightness, filleted corners, beveled projections, bracing, alignment, removal, reuse and wetting shall also apply to metal forms, except that these will not require lining, unless specifically indicated on the drawings.

The thickness of form metal shall be as required to maintain the true shape without warping or bulging. All bolt and rivet heads on the facing sides shall be countersunk. Clamps, pins or other connecting devices shall be designed to hold the forms rigidly together and to allow removal without injury to the concrete. Metal forms, which do not present a smooth surface or line up properly, shall not be used. Metal shall be kept free from rust, grease or other foreign materials.

D. Form Supports for Overhang Slabs

Form supports which transmit a horizontal force to a steel girder or beam or to a prestressed concrete beam will be permitted, but shall not be used unless a structural analysis has been made of the affect on the girder or beam and approval is granted by the Engineer or designated representative.

In normal or skewed spans with standard overhangs not exceeding 3 feet, 1 1/2 inches (0.95 meter), beam bracing as shown in the drawings shall be used.

Spans in which the overhang width exceeds 3 feet, 1 1/2 inches (0.95 meter) will require additional support for the outside beams to resist torsion. Details of the Contractor's proposed method of providing additional support shall be included with the slab forming plans submitted to the Engineer or designated representative for review and approval.

Holes in steel members for support of overhang brackets may be punched or drilled full size or may be torch cut to 1/4 inch (6 mm) under size and reamed full size. In no case shall the holes be burned full size. The hole shall be left open unless indicated to be filled with a button head bolt. They shall never be filled by welding.

410S.11 Placing Reinforcement

Reinforcement in concrete structures shall be placed carefully and accurately and rigidly supported as provided in Standard Specification Item No. 406S, "Reinforcing Steel". Reinforcing steel supports shall not be welded to I-beams or girders or stirrups of prestressed concrete beams.

410S.12 Placing Concrete

A. General

Concrete shall not be placed when impending weather conditions would impair the quality of the finished work. If conditions of wind, humidity and temperature are such that concrete cannot be placed without the potential for shrinkage cracking, the concrete should be placed in early morning, at night or on a schedule with more favorable weather. When mixing, placing and finishing concrete is scheduled during non-daylight hours; the entire placement site should be illuminated to the satisfaction of the Engineer or designated representative.

If changes in weather conditions require protective measures after work starts, adequate shelter shall be provided to protect the concrete against damage from rainfall or from freezing temperatures as outlined in this Item. Operations during rainfall shall only be continued if approved by the Engineer or designated representative. Aggregate stockpiles shall be covered to the extent necessary to control the moisture conditions in the aggregates.

Slab concrete shall be mixed in a plant located off the structure. Carting or wheeling concrete batches over completed slabs will not be permitted until they have aged at least 4 full curing days or timber planking placed on top of the slab for the carts to traverse along. Carts shall be equipped with pneumatic tires. Curing operations shall not be interrupted for the purpose of wheeling concrete over finished slabs.

Exposed concrete surfaces, while still plastic, shall be stamped with an impression having the Contractor's name, the month and year. The stamp shall be of an approved design.

At least 1 day of curing shall be allowed after the concrete has achieved initial set before placing strain on projecting reinforcement to prevent damage to the concrete.

The storing of reinforcing or structural steel on completed roadway slabs generally shall be avoided and when permitted, shall be limited to quantities and distribution that will not induce excessive stresses.

B. Preparation of Surfaces

All forms, prestressed concrete panels, T-beams and concrete box beams on which concrete will be placed shall be thoroughly wetted before the placement of concrete. Puddles of excess water shall be removed before placing the concrete. The various surfaces shall be in a moist, saturated surface dry condition when concrete is placed on or against them.

The subgrade or foundation shall be moist before placing concrete for bridge approach slabs or other concrete placed on grade. If dry the subgrade shall be lightly sprinkled.

C. Placing Temperature

The minimum temperature of all concrete at the time of placement shall not be less than 50°F (10°C). The maximum temperature of any concrete, unless otherwise indicated on the drawings, shall not exceed 95°F (35°C) when placed. The maximum temperature of cast-in-place concrete in bridge superstructures, diaphragms, parapets, concrete portions of railing, curbs and sidewalks and direct traffic box culverts shall not exceed 85°F (30°C) when placed. Other portions of structures, when indicated on the drawings, shall require the temperature control specified.

For continuous placement of the deck on continuous steel units, the initial set of the concrete shall be retarded sufficiently to insure that it remains plastic in not less than 3 spans immediately preceding the one being placed. For simple spans, retardation shall be required only if necessary to complete finishing operations.

The consistency of the concrete as placed should allow the completion of all finishing operations without the addition of water to the surface. When conditions are such that additional moisture is needed for finishing, the required water shall be applied to the surface by fog spray only and shall be held to a minimum amount. Fog spray for this purpose may be applied with hand operated fogging equipment.

The height of free fall of concrete shall be limited to 5 feet (1.575 meters) to prevent segregation.

D. Transporting Time

The maximum time interval between the addition of cement to the batch and the placing of concrete in the forms shall not exceed the following:

Table 2: Allowable Transportation Times			
Air or Concrete Temperature whichever is higher	Maximum Time w/o Retarder	Maximum Time with Retarder	
		*Specific Applications	All others
Non-agitated Concrete			
35°F to 79°F (2°C to 26°C)	45 minutes	45 minutes	45 minutes
Over 80°F (Over 25°C)	30 minutes	45 minutes	45 minutes
Agitated Concrete			
90°F (32°C) or above	45 minutes	75 minutes	105 minutes
75°F to 89°F (24°C to 32°C)	60 minutes	90 minutes	120 minutes
35°F to 74°F (2°C to 23°C)	90 minutes	120 minutes	150 minutes

* Specific applications include Bridge decks, cased drilled shafts and slabs of direct traffic culverts

The use of an approved retarding agent in the concrete will permit the extension of each of the above temperature-time maximums by 30 minutes for bridge decks, top slabs of direct traffic culverts and cased drilled shafts and 1 hour for all other concrete except that the maximum time shall not exceed 45 minutes for non-agitated concrete.

E. Handling and Placing

The Contractor shall give the Engineer or designated representative sufficient advance notice before placing concrete in any unit of the structure to permit the review of forms, reinforcing steel placement and other preparations. Concrete shall not be placed in any unit prior to the completion of formwork and placement of reinforcement therein.

The sequence for placing concrete shall be as indicated on the drawings or as required herein. The placing shall be regulated so the pressures caused by the plastic concrete shall not exceed the loads used in the form design.

The method of handling, placing and consolidation of concrete shall minimize segregation and displacement of the reinforcement and produce a uniformly dense and compact mass. Concrete shall not have a free fall of more than 5 feet (1.5 meters), except in the case of drilled shafts, thin wall sections such as in culverts, or as allowed by other Items. Any hardened concrete spatter ahead of the plastic concrete shall be removed.

Each part of the forms shall be filled by depositing concrete as near its final position as possible. The coarse aggregate shall be worked back from the face and the concrete forced under and around the reinforcement bars without displacing them. Depositing large quantities at one point and running or working it along the forms will not be allowed.

Concrete shall be deposited in the forms in layers of suitable depth but not more than 36 inches (0.9 meter) in thickness, unless otherwise directed by the Engineer or designated representative.

Cold joints in a monolithic placement shall be avoided. The sequence of successive layers or adjacent portions of concrete shall be such that they can be vibrated into a homogeneous mass with the previously placed concrete without a cold joint. Not more than 1 hour (1 ½ hours if a normal dosage of retarding admixture is used) shall elapse between adjacent or successive placements of concrete. Unauthorized construction joints shall be avoided by placing all concrete between the authorized joints in one continuous operation.

An approved retarding agent shall be used to control stress cracks and/or authorized cold joints in mass placements where differential settlement and/or setting time may induce stress cracking, such as on false work, in deep girder stems, etc.

Openings in forms shall be provided, if needed, for the removal of laitance or foreign matter of any kind.

All forms shall be wetted thoroughly before the concrete is placed therein.

F. Consolidation

All concrete shall be carefully consolidated and the mortar flushed to the form surfaces by continuous working with immersion type vibrators. Vibrators which operate by attachment to forms or reinforcement will not be permitted, except on steel forms. At least 1 standby vibrator shall be provided for emergency use in addition to the ones required for placement. For lightweight concrete, vibrators of the high frequency type, which produce a minimum of 7000 impulses per minute, will be required.

The concrete shall be vibrated immediately after deposition. Prior to the beginning of work, a systematic spacing of the points of vibration shall be established to insure complete consolidation and thorough working of the concrete around the reinforcement, embedded fixtures and into the corners and angles of the forms. Immersion type vibrators shall be inserted vertically, at points 18 to 30 inches (450 to 750 mm) apart and slowly withdrawn. The vibrator may only be inserted in a sloping or horizontal position in shallow slabs. The entire depth of each lift shall be vibrated, allowing the vibrator to penetrate several inches (several cms) into the preceding lift. The vibrator shall not be used to move the concrete to other locations. In addition the vibrator shall not be dragged through the concrete. Concrete along construction joints shall be thoroughly consolidated by operating the vibrator along and close to but not against the joint surface. The vibration shall continue until thorough consolidation and complete embedment of reinforcement and fixtures is produced, but not long enough to cause segregation. Vibration may be supplemented by hand spading or rodding, if necessary, to insure the flushing of mortar to the surface of all forms.

G. Finishing

From the time of initial strike off until final finish is completed and required interim curing is in place, the unformed surfaces of slab concrete in bridge decks and top slab of direct traffic culverts and concrete slabs, shall be kept damp, not wet, to offset the effects of rapid evaporation of mixing water from the concrete due to wind, temperature, low humidity or combinations thereof. Fogging equipment capable of applying water in the form of a fine fog mist, not a spray, will be required. Fogging will be applied at the times and in the manner directed by the Engineer or designated representative.

Fogging equipment may be either water pumped under high pressure or a combination of air and water, either system in combination with a proper atomizing nozzle. The equipment shall be sufficiently portable for use in the direction of any prevailing winds. The equipment shall be adapted for intermittent use to prevent excessive wetting of the surfaces.

Upon completion of the final finish, interim curing will be required for slab concrete in bridge decks and top slabs of direct traffic culverts as follows:

- (1) Required water curing shall begin as soon as it can be done without damaging the concrete finish.
- (2) Unless otherwise indicated on the Drawings, Type 1-D membrane curing compound that conforms to TxDOT DMS-4650, "Hydraulic Cement Concrete Curing Materials and Evaporation Retardants" shall be applied to the slab surface.

H. Installation of Dowels and Anchor Bolts

Dowels and anchor bolts shall be installed by casting them in place or by grouting with grout, epoxy, or epoxy mortar unless indicated otherwise on the drawings.

Holes for grouting shall be formed or drilled. Holes for anchor bolts shall be drilled to accommodate the bolt embedment required on the drawings. Holes for dowels shall be made at least 12 in. (300 mm) deep unless indicated otherwise on the drawings. When grout or epoxy mortar is specified the diameter of the hole shall be at least twice the dowel or bolt diameter but shall not exceed the dowel or bolt diameter plus 1 ½ in (38 mm). When epoxy is specified the hole diameter should be 1/16 to ¼ in. (1.6 to 6.35 mm) greater than the dowel or bolt diameter.

Holes for anchor bolts in piers, abutments, bents or pedestals may be drilled or formed by the insertion of oiled wooden plugs or metal sleeves in the plastic concrete. Formed holes shall be large enough to permit horizontal adjustments of the bolts. The bolts shall be carefully set in mortar. In lieu of the above, anchor bolts may be set to exact locations when the concrete is placed.

The holes shall be thoroughly cleaned of all loose material, oil, grease or other bond-breaking substance and blow them clean with filtered compressed air. When an epoxy type material is used the holes shall be in a surface dry condition. When hydraulic cement grout is used the holes shall be in a surface moist condition. The void space between the hole and the dowel or bolt shall be completely filled with grouting material. The requirements for cleaning outlined in the product specification for prepackaged systems shall be followed exactly.

The following should be used as a guide in selection of an appropriate grout, mortar, epoxy or epoxy grout.

Table 3: Guide for Selection of Epoxy, Epoxy Mortar, Grout and Epoxy Grout

Material Type	Recommendation
Epoxy, Epoxy Mortar or other prepackaged Mortar	As Approved
Cast-in-place or Grouted system	1 part hydraulic cement, 2 parts sand and

	sufficient water for desired consistency
Neat Epoxy	Type III epoxy per TxDoT DMS-6100, "Epoxies and Adhesives"
Epoxy Grout	Type III epoxy per TxDoT DMS-6100, "Epoxies and Adhesives"
Provide grout, epoxy or epoxy mortar as the binding agent unless otherwise indicated on the drawings	

410S.13 Placing Concrete in Cold Weather

A. General

The Contractor is responsible for the protection of concrete placed under any and all weather conditions and is responsible for producing concrete equal in quality to that placed under normal conditions. Permission given by the Engineer or designated representative to allow placement of the concrete during cold weather does not relieve the Contractor of the responsibility for producing concrete equal in quality to that placed under normal conditions. Concrete placed under adverse weather conditions that proves to be unsatisfactory shall be removed and replaced at Contractor' expense.

B. Cast-in-Place Concrete

Concrete may be placed when the ambient temperature is not less than 35°F (2°C) in the shade and rising or above 40°F (4°C). Concrete shall not be placed when the ambient temperature in the shade is below 40°F (4°C) and falling unless approved by the Engineer or designated representative. Concrete shall not be placed in contact with any material coated with frost or having a temperature less than 32°F (0°C).

Aggregates shall be free from ice, frost and frozen lumps. When required, in order to produce the minimum specified concrete temperature; the aggregate and/or the water shall be heated uniformly, in accordance with the following:

The water temperature shall not exceed 180°F(82°C) and/or the aggregate temperature shall not exceed 150°F(66°C). The heating apparatus shall heat the mass of aggregate uniformly. The temperature of the mixture of aggregates and water shall be between 50°F(10°C) and 85°F(29°C) before introduction of the cement.

All concrete shall be effectively protected as follows:

1. The temperature of slab concrete of all unformed surfaces shall be maintained at 50°F(10°C) or above for a period of 72 hours from time of placement and above 40°F(4°C) for an additional 72 hours.
2. The temperature at the surface of all concrete in bents, piers, culvert walls, retaining walls, parapets, wingwalls, bottom of slabs and other similar forms shall be maintained at 40°F(4°C) or above for a period of 72 hours from time of placement.
3. The temperature of all concrete, including the bottom slabs of culverts placed on or in the ground, shall be maintained above 32°F(0°C) for a period of 72 hours from time of placement.

Protection shall consist of providing additional covering, insulated forms or other means and if necessary, supplementing such covering with artificial heating. Avoid applying heat directly to concrete surfaces. Curing shall be provided during this period until all requirements for curing have been satisfied.

When impending weather conditions indicate the possibility of the need for such temperature protection, all necessary heating and covering material shall be on hand ready for use before permission is granted to begin placement.

Sufficient extra test specimens will be made and cured with the placement to ascertain the condition of the concrete as placed prior to form removal and acceptance.

C. Precast Concrete

A fabricating plant for precast products which has adequate protection from cold weather in the form of permanent or portable framework and covering, which protects the concrete when placed the forms and is equipped with approved steam curing facilities may place concrete under any low temperature conditions provided:

1. The framework and covering are placed and heat is provided for the concrete and the forms within 1 hour after the concrete is placed. This shall not be construed to be 1 hour after the last concrete is placed, but that no concrete shall remain unprotected longer than 1 hour.
2. Steam heat shall keep the air surrounding the concrete between 50°F (10°C) and 85°F (29°C) for a minimum of 3 hours prior to beginning the temperature rise, which is required for steam curing.

410S.14 Placing Concrete in Hot Weather

When the temperature of the air is above 85°F (29°C), an approved retarding agent will be required in all exposed concrete, concrete used in superstructures, top slabs of direct traffic culverts and all cased drilled shafts regardless of temperatures. Concrete mix temperatures shall not exceed 90°F (32°C) except for mixes that include high range water reducers where a maximum mix temperature of 100°F (38°C) will be allowed.

If the concrete mix temperature is expected to exceed 90°F (32°C) (or 100°F (38°C) in mixes with high range water reducers) ice may be utilized to lower the concrete mix temperature. Ice may be added to the concrete mix as a portion by weight of the mix water. However the addition of ice shall not exceed 50% of the total mix water weight.

When weather conditions are such that the addition of ice at 50% of the mix water is not sufficient to reduce the concrete mix temperature to an acceptable temperature, concrete work shall not be allowed.

When ice is to be used in hot weather concrete placement, the Contractor shall furnish a mix design (Section 4.4 of Standard Specification Item 360S, "Concrete Pavement" and Section 6 of Standard Specification Item No. 403S, "Concrete for Structures") acceptable to the Engineer or designated representative for class of concrete specified on the drawings.

410S.15 Placing Concrete in Water

Concrete shall be deposited in water only when indicated on the drawings or with written permission of the Engineer or designated representative. The forms, cofferdams or caissons shall be sufficiently tight to prevent any water current passing through the space in which the concrete is being deposited. Pumping will not be permitted during the concrete placing nor until it has set for at least 36 hours.

The concrete shall be placed with a tremie, pump or other approved method and shall not be permitted to fall freely through the water nor shall it be disturbed after it has been placed. Its surface shall be kept approximately level during placement.

The tremie shall be supported or the pump operated so that it can be easily moved horizontally to cover all the work area and vertically to control the concrete flow. The lower end of the tremie or pump hose shall be submerged in the concrete at all times.

The placing operations shall be continuous until the work is complete.

For concrete to be placed under water, the concrete mix shall be designed in accordance with Standard Specification Item No. 403S, "Concrete For Structures" with a minimum cement content of 650 lb. Per cubic yard (10.4 Mg per cubic meter). An anti-wash admixture may be included in the mix design as necessary to produce a satisfactory finished product.

410S.16 Placing Concrete in Superstructure

A. General

Unless otherwise indicated on the drawings, simple span roadway slabs shall be placed without transverse construction joints by using a mechanical longitudinal screed or a self-propelled transverse finishing machine or a mechanical longitudinal screed. For small placements or unusual conditions such as narrow widening, variable cross-slopes, or transitions, manually operated screeding equipment may be used if approved by the Engineer or designated representative.

B. Transverse Screeding

Unless otherwise indicated on the drawings, slabs on continuous units shall be placed in one continuous operation without transverse construction joints using a longitudinal screed or a self-propelled transverse finishing machine. Rails for transverse finishing machines supported from the beams or girders shall be installed so they may be removed without damage to the slab. Bond between removable supports and the concrete shall be prevented in a manner acceptable to the Engineer or designated representative. Rail support parts, which remain embedded in the slab, shall not project above the upper mat of reinforcing steel. Rail or screed supports attached to I-beams or girders shall be subject to "General Requirements" stated above. Unless indicated otherwise on the drawings, the minimum rate of concrete placement is 30 lineal feet (9.144 lineal meters) of bridge slab per hour. The concrete shall be deposited parallel to the skew of the bridge so that all girders are loaded uniformly along their length. Slab concrete shall be deposited between the exterior beam and the adjacent beam before placing concrete in the overhang portion of the slab. Personnel and equipment shall be furnished that is capable of placing, finishing and curing the slab at an acceptable rate to ensure compliance with this Item. Concrete shall be placed in transverse strips. On profile grades greater than 1.5 %, placement shall be started at the lower end.

C. Longitudinal Screeding

The screed shall be adequately supported on a header or rail system sufficiently stable to withstand the longitudinal or lateral thrust of the equipment. Unless otherwise indicated on the drawings, temporary intermediate headers will be permitted for placements exceeding 50 feet (15.24 meters) in length for the longitudinal screed, provided the rate of placement is rapid enough to prevent a cold joint and these headers are designed for early removal to permit satisfactory consolidation and finish of the concrete at their locations. The slab concrete shall be deposited between the exterior beam and the adjacent beam before placing concrete in the overhang portion of the slab.

For longitudinal screeding, concrete shall be placed in longitudinal strips starting at a point in the center of the segment adjacent to one side, except as provided herein and the strip completed by placing uniformly in both directions toward the ends except that for spans on a grade of 1.5 percent or more, placing shall start at the lower end. The width of strips shall be such that the concrete therein will remain plastic until the adjacent strip is placed. Where monolithic curb construction is specified, the concrete shall be placed therein in proper sequence to be monolithic with the adjacent longitudinal strips of the slabs.

D. Placements on Continuous Steel Units

Unless otherwise indicated on the drawings, slabs on continuous steel units shall be placed in a single continuous operation without transverse construction joints using a mechanical longitudinal screed or a self-propelled transverse finishing machine. The initial set of the concrete shall be retarded sufficiently to ensure that concrete remains plastic in at least 3 spans immediately preceding the slab being placed. Construction joints shall be used, when required for slab placements on steel beams or girders, as shown on the drawings. When staged placement of a slab is specified in the drawings, it shall be necessary to ensure that the previously placed concrete attains a compressive strength of 3000 psi (20.7 MPa) before placing the next stage concrete. Multiple stages may be placed in a single day if approved by the Engineer or designated representative. When drawings permit staged concrete placement without specifying a particular order of placement, a placing sequence that will not overstress any of the supporting members shall be submitted for the approval of the Engineer or designated representative.

E. Slab and Girder Units

Unless indicated otherwise on the drawings, girders, slab and curbs of slab and girder spans shall be placed monolithically. Concrete girders shall be filled first, and the slab concrete placed within the time limits specified in this Item. If a transverse screed is used, the concrete shall be placed in the stem for a short distance and then the concrete placed in transverse strips. If a longitudinal screed is used, the concrete shall be placed in the outside girder stem first beginning at the low end or side, and then continue the concrete placed in longitudinal strips.

410S.17 Placing Concrete in Concrete Arches

Concrete shall be placed in arch rings so the loading is kept symmetrical on the falsework. The arch rings and ribs shall be placed in one continuous operation unless otherwise

indicated on the drawings or permitted by the Engineer or designated representative. The spandrel walls or columns and the beams shall not be placed until the arch is swung. Floor slab, railing, parapet walls, etc., shall not be placed until all spandrels are complete. Slab placement shall be symmetrical about the transverse centerline so the loading of the arch is kept approximately symmetrical.

The placing sequence shall be as indicated on the drawings.

410S.18 Placing Concrete in Box Culverts

In general, construction joints will be permitted only where indicated on the drawings.

Where the top slab and walls are placed monolithically in culverts more than 4 feet (1.22 meters) in clear height, an interval of not less than 1 nor more than 2 hours shall elapse before placing the top slab to allow for settlement and shrinkage in the concrete wall.

The base slab shall be trowel finished accurately at the proper time to provide a smooth uniform surface. Top slabs, which carry traffic, shall be finished as specified for roadway slabs in "Finish of Roadway Slabs", below. Top slabs of fill type culverts shall be given a reasonably smooth float finish.

410S.19 Placing Concrete in Foundations and Substructure

Concrete shall not be placed in footings until the depth and character of the foundation has been inspected by the Engineer or designated representative and permission has been given to proceed.

Placing of concrete footings upon seal courses will be permitted after the caissons or cofferdams are free from water and the seal course cleaned. Any necessary pumping or bailing during the concrete placement shall be done from a suitable sump located outside the forms.

All temporary wales or braces inside cofferdams or caissons shall be constructed or adjusted as the work proceeds to prevent unauthorized construction joints in footings or shafts.

When footings can be placed in a dry excavation without the use of cofferdams or caissons, forms may be omitted if desired by the Contractor and approved by the Engineer or designated representative and the entire excavation filled with concrete to the elevation of the top of footing.

Concrete in columns shall be placed monolithically unless otherwise indicated on the drawings. Columns and caps and/or tie beams supported thereon may be placed in the same operation or separately. To allow for settlement and shrinkage of the column concrete, it shall be placed on the lower level of the cap or tie beam and placement delayed for not less than 1 hour nor more than 2 before proceeding with the cap or tie beam placement.

410S.20 Treatment and Finishing of Horizontal Surfaces Except Bridge Slabs

All unformed upper surfaces shall be struck off to grade and finished. The use of mortar topping for surfaces under this classification will not be permitted.

After the concrete has been struck off, the surface shall be floated with a suitable float. Bridge sidewalks shall be given a wood float or broom finish or may be striped with a brush as specified by the Engineer or designated representative.

The tops of caps and piers between bearing areas shall be sloped slightly from the center toward the edge and the tops of abutments and transition bents sloped from the back wall to the edge, as directed by the Engineer or designated representative, so that water will drain from the surface. The concrete shall be given a smooth trowel finish. Bearing areas for steel units shall be constructed in such a manner to have a full and even bearing upon the concrete. When the concrete is placed below grade, bearing areas may be raised to grade on beds of Portland cement mortar consisting of 1 part cement, 2 parts sand and a minimum amount of water.

Bearing seat buildups or pedestals for concrete units shall be cast integrally with the cap or with a construction joint. The construction joint area under the bearing shall have the surface roughened thoroughly as soon as practical after initial set is obtained. The bearing seat buildups shall be placed using a latex based grout, an epoxy grout, or an approved proprietary bearing mortar, mixed in accordance with the manufacturer's recommendation. Pedestals shall be placed using Class C concrete, reinforced as indicated on the drawings.

The bearing area under the expansion end of concrete slabs and slab and girder spans shall be given a steel-trowel finish to the exact grades required on the drawings. Bearing areas under elastomeric bearing pads or nonreinforced bearing seat buildups shall be given a textured wood float finish. The bearing area shall not vary from a level plane more than 1/16 in. (1.6 mm) in all directions.

410S.21 Finish of Bridge Slabs

In all roadway slab-finishing operations, camber for specified vertical curvature and transverse slopes shall be provided.

For concrete flat slab and concrete slab and girder spans cast in place on falsework, an additional amount of camber shall be provided to offset the initial and final deflections of the span indicated in the drawings. For concrete slab and girder spans using pan forms, a camber of approximately 3/8 in. for 30 ft. (9.5 mm for 9.14 meter) spans and 1/2 in. for 40 ft. (12.7 mm for 12.19 meter) spans shall be provided to offset initial and final deflections unless otherwise directed by the Engineer or designated representative. When dead load deflection requirements for concrete flat slab and concrete slab and girder spans not using pan forms is not indicated on the drawings, the additional amount of camber shall be 1/8 inch per 10 foot (3.2 mm per 3 meter) of span length but not to exceed 1/2 inch (12.7 mm).

Bridge slabs supported on prestressed concrete beams, steel beams or girders shall receive no additional camber, except that for slabs without vertical curvature, the longitudinal camber shall be approximately 1/4 inch (6.35 mm).

Work bridges or other suitable facilities shall be provided from which to perform all finishing operations and to provide access, if necessary, for the Engineer or designated representative to check measurements for slab thickness and reinforcement cover.

As soon as the concrete has been placed and vibrated in a section of sufficient width to permit working, the surface shall be struck off, leveled and screeded, carrying a slight excess of concrete ahead of the screed to insure filling of all low spots. The screed shall be designed rigid enough to hold true to shape and shall have sufficient adjustments to provide for the required camber. A vibrating screed shall be used in all slabs more than 20 feet (6.1 meters) in width. A vibrating screed may be used if heavy enough to prevent undue distortion. The screeds shall be provided with a metal edge.

Longitudinal screeds shall be moved across the concrete with a saw like motion while their ends rest on headers or templates set true to the roadway grade or on the adjacent finished slab. The transverse screeds shall be moved longitudinally approximately 1/5 of the drum length for each complete out-and-back pass of the carriage.

The surface of the concrete shall be screeded a sufficient number of times and at such intervals to produce a uniform surface, true to grade and free of voids. If necessary, the screeded surface shall be worked to a smooth finish with a long handled wood or metal float of the proper size or hand floated from bridges over the slab. Floating may not be necessary if the pan float attached to a transverse screed produces an acceptable finish. Overworking the concrete surface and overuse of finish water shall be avoided.

The Contractor shall perform in the presence of the Engineer or designated representative sufficient checks with a long handled 16-foot (5 meter) straightedge on the plastic concrete to insure that the final surface will be within the specified tolerances. The check shall be made with the straightedge parallel to the centerline. Each pass thereof shall lap half of the preceding pass. All high spots shall be removed and all depressions over 1/16 inch (1.6 mm) in depth shall be filled with fresh concrete and floated. The checking and floating shall be continued until the surface is true to grade and free of depressions, high spots, voids or rough spots.

Screed-rail support holes shall be filled with concrete and finished to match the top of the slab.

The concrete surface shall be finished to a uniform texture using a carpet drag, burlap drag or broom finish. The surface shall be finished to a smooth sandy texture without blemishes, marks or scratches deeper than 1/16 inch (1.6 mm). The surface texturing shall be applied using a work bridge or platform immediately after completing the straightedge checks. The carpet or burlap drag shall be drug longitudinally along the concrete surface, adjusting the surface contact area or pressure to provide a satisfactory coarsely textured surface. A broom finish may be performed using a fine bristle broom transversely.

The concrete surface shall be coated immediately after the carpet or burlay drag, or broom finish with a single application of evaporation retardant at a rate recommended by the manufacturer. The time between the texturing at any location and subsequent application of evaporation retardant shall not exceed 10 minutes. The evaporation retardant may be applied using the same workbridge used for surface texturing. The concrete surface shall not be worked once the evaporation retardant has been applied.

Interim and final curing shall be applied in accordance with Section P410S.23, "Curing Concrete".

The Contractor is responsible for the ride quality of the finished bridge slab. The Engineer or designated representative will use a 10-ft. (3.05 meter) straightedge to verify ride quality [1/8 in. or less in 10 ft (3.2 mm or less in 3.05 meters)] and to determine locations where

corrections are needed. If the Engineer or designated representative determines that the ride quality is unacceptable, then the Contractor shall submit to the Engineer or designated representative for approval a plan to produce a ride of acceptable quality. All corrections for ride-quality shall be made before saw-cutting grooves.

At the option of the Contractor or when indicated on the drawings, the hardened concrete surface of bridge slabs, bridge approach slabs and direct-traffic culverts shall be given its final texture by saw grooving to meet the above requirements after completion of the required curing period. Grooves shall be cut perpendicular to the structure centerline. The grooves shall be cut continuously across the slab to within 18 in. (450 mm) of the barrier rail, curb or median divider. At skewed metal expansion joints in bridge slabs, groove cutting shall be adjusted by using narrow-width cutting heads so that all grooves end within 6 in. (150 mm) of the joint, measured perpendicular to the centerline of the metal joint. There should not be any ungrooved surface wider than 6 in. (150 mm) adjacent to either side of the joint. The minimum distance to the first groove, measured perpendicular to the edge of the concrete joint or from the junction between the concrete and the metal leg of the joint shall be 1 in. (25 mm). Grooves shall be continuously cut across construction joints or other joints in the concrete that are less than ½ in. (13 mm) wide. The same procedure described above shall be used where barrier rails, curbs or median dividers are not parallel to the structure centerline in order to maintain the 18-in. (450-mm) maximum dimension from the end of the grooves to the gutter line. The grooves shall be cut continuously across formed concrete joints.

When the plans require that a concrete overlay be placed on the slab (new construction) or on prestressed concrete box beams or other precast elements, a carpet drag, burlap drag or broom finish shall be given to all concrete surfaces to be overlaid. Saw grooving is not necessary in this case. An average texture depth for the finish of approximately 0.035 in. (0.9 mm) shall be provided with no individual test falling below 0.020 in. (0.5 mm), unless otherwise indicated on the drawings, when tested in accordance with TxDOT's Tex-436-A, "Measurement of Texture Depth by the Sand Patch Method". If the texture depth falls below what is specified, the finishing procedure shall be revised to produce the desired texture.

When the drawings require an asphalt seal with or without overlay on the slab (new construction), on prestressed concrete box beams or on other precast elements, all concrete surfaces to be covered shall be given a lightly textured broom or carpet drag finish, similar to a sidewalk finish having an average texture depth of approximately 0.025 inch (0.635 mm), when tested in accordance with TxDOT's Tex-436-A, “.

410S.22 Placing Survey Monuments

The Contractor shall obtain City Survey Monuments, for a fee of 10 dollars, from the Department of Public Works, Construction Inspection Division. Monuments shall be embedded in freshly poured concrete at locations indicated on the drawings and accessible to survey equipment at the completion of the project. The monuments shall be installed flush with the adjacent concrete.

410S.23 Curing Concrete

The Contractor shall inform the Engineer or designated representative fully of the methods and procedures proposed for curing, shall provide the proper equipment and material in adequate amounts and shall have the proposed method, equipment and material approved by the Engineer or designated representative prior to placing concrete.

Inadequate curing and/or facilities therefore shall be cause for the Engineer or designated representative to notify the Contractor, in writing, that the work is unsatisfactory and the concrete will have to be removed and replaced.

All concrete shall be cured for a period of 4 curing days except as noted herein. A curing day is a calendar day when the temperature, taken in the shade away from artificial heat is above 50°F (10°C) for at least 19 hours or on colder days if the temperature of all surfaces of the concrete is maintained above 40°F (4°C) for the entire 24 hours. The required curing shall begin when all concrete has attained its initial set. TxDOT's Tex-440-A, "Initial Time-of-Set of Fresh Concrete" may be used to establish when the concrete has attained its initial set.

Table 4: Exceptions to 4-Day Curing

Description	Type of Cement	Required Curing Days
Upper Surfaces of Bridge Slabs, Top Slabs of Direct Traffic Culverts and Concrete Overlays	I or II	8
	II or I/II	10
	All types with supplementary cementing materials	10
Concrete Piling buildups		6

For upper surfaces of bridge slabs, bridge support slabs, median and sidewalk slabs and culvert top slabs constructed using Class S Concrete (Standard Specification Item No. 403S, "Concrete for Structures") interim curing using a Type 1-D curing compound shall be applied as soon as possible after application of the evaporation retardant and after the water sheen has disappeared, but no more than 45 minutes after application of the evaporation retardant. Membrane interim curing shall be applied using a work bridge or other approved apparatus to ensure a uniform application. Final curing with water cure in accordance with this section shall start as soon as possible without damaging the surface finish. Water curing shall be maintained for the duration noted in the table above. Polyethylene sheeting, burlap-polyethylene blankets, laminated mats or insulating curing mats shall be placed in direct contact with the slab when the ambient temperature is expected to drop below 40°F (4°C) during the first 72 hours of the curing period. The curing materials will be weighed down with dry mats to maintain direct contact with the concrete and to provide insulation against cold weather. Supplemental heating or insulation may be required in cold and wet weather if the insulating cotton mats become wet or if the concrete temperature drops below the specified curing temperature. Application of heat directly to concrete surfaces shall be avoided.

For the top surface of any concrete unit upon which concrete is to be placed and bonded at a later date (i.e. stub walls, risers, etc.), only water-cure in accordance with this Section shall be used.

All other concrete shall be cured as specified in pertinent Items.

The following methods are permitted for curing concrete subject to the restrictions of this Item .

A. Form Curing

When forms are left in intimate contact with the concrete, other curing methods will not be required except for exposed surfaces and for cold weather protection.

When forms are striped before the 4-day minimum curing time has elapsed, curing shall continue by an approved method.

B. Water Curing

All exposed surfaces of the concrete shall be kept wet continuously for the required curing time. The water used for curing shall meet the requirements for concrete mixing water as indicated in Item No. 403S, "Concrete for Structures". Seawater will not be permitted. Water, which stains or leaves an unsightly residue, shall not be used.

1. Wet Mats

Wet cotton mats placed in direct contact with the slab shall be maintained for the required curing time. If needed damp burlap blankets made from 9-ounce (255 gm) stock may be placed on the damp concrete surface for temporary protection prior to the application of the cotton mats, which may be placed dry and wetted down after placement.

The mats shall be weighted down adequately to provide continuous contact with all concrete surfaces where possible. The surfaces of the concrete shall be kept wet for the required curing time. Surfaces, which cannot be cured by contact, shall be enclosed with mats, anchored positively to the forms or to the ground, so that outside air cannot enter the enclosure. Sufficient moisture shall be provided inside the enclosure to keep all surfaces of the concrete wet.

2. Water Spray

This method shall consist of overlapping sprays or sprinklers that keep all unformed surfaces continuously wet.

3. Ponding

This method requires the covering of the surfaces with a minimum of 2 inches (50 mm) of clean granular material, kept wet at all times or a minimum of 1 inch (25 mm) depth of water. Satisfactory provisions shall be made to provide a dam to retain the water or saturated granular material.

C. Membrane Curing

Unless otherwise indicated on the drawings, either Type 1-D or Type 2 membrane curing compound may be used where permitted except that Type 1-D (Resin Base Only) will be permitted for slab concrete in bridge decks and top slabs of direct traffic culverts and all other surfaces that require a higher grade of surface finish. For substructure concrete, only one Type of curing compound will be permitted on any one structure.

TABLE 5

STRUCTURE UNIT DESCRIPTION	REQUIRED		PERMITTED	
	Water for Complete Curing	Membrane for Interim Curing	Water for Complete Curing	Membrane for Complete Curing
1. Upper surfaces of Bridge Roadway, Median and Side walk Slabs, Top Slabs of Direct Traffic, and Culverts.	X	X (resin base)		
2. Top Surface of any Concrete Unit upon which Concrete is to be placed and bonded at a later interval (Stub Walls, Risers, etc.). Other Superstructure Concrete (curbs, wing-walls, Parapet Walls, etc.).	X		*X	*X
3. Top Surface of Precast and/or Prestressed Piling.	X	X		
4. All Substructure Concrete Culverts. Box Sewers, Inlets, Manholes, Retaining Walls, Riprap.			*X	*X

* Polyethylene Sheeting, Burlap-Polyethylene Mats or Laminated Mats in close intimate contact with the concrete surfaces, will be considered equivalent to water or membrane curing for items under 4.

The membrane curing shall be applied just after free moisture has disappeared in a single, uniform coating at the rate of coverage recommended by the manufacturer and as approved by the Engineer or designated representative, but not less than 1 gallon per 180 square feet (1 liter per 4.4 square meters) of area. Tests for acceptance shall be at this specified rate.

Membrane curing shall not be applied to dry surfaces, but shall be applied just after free moisture has disappeared. Formed surfaces and surfaces which have given a first rub shall be dampened and shall be moist at the time of application of the membrane.

When membrane is used for complete curing, the film shall remain unbroken for the minimum curing period specified. Membrane, which is damaged, shall be corrected immediately by reapplication of membrane. Polyethylene sheeting, burlap-polyethylene mats or laminated mats in close intimate contact with the concrete surfaces, will be considered equivalent to membrane curing. Unless otherwise indicated on the drawing, the choice of membrane type shall be at the option of the Contractor, except that the Engineer or designated representative may require the same curing method for like portions of a single structure.

410S.24 Removal of Forms and Falsework

Unless otherwise indicated on the drawing, forms for vertical surfaces may be removed when the concrete has aged 12 hours after initial set, provided it can be done without damage to the concrete. Forms for mass concrete placements shall be maintained in place for 4-days following concrete placement. Mass placements are defined as concrete placements with a least dimension greater than equal to 5 ft. (1.575 meters), or those designated as such on the drawings.

Forms for inside curb faces may be removed in approximately 3 hours provided it can be done without damage to the curb.

Unless indicated otherwise on the drawings weight supporting forms and falsework spanning more than 1 ft. (300 mm) for structures, bridge components and culvert slabs shall remain in place until the concrete has attained a minimum compressive strength of 2500 psi (17.25 MPa). Forms for other structural components may be removed as specified by the Engineer or designated representative.

Inside forms (walls and top slabs) for inlets, box culverts and sewers may be removed after the concrete has attained a minimum compressive strength of 1800 psi (12.4 MPa), provided an overhead support system, approved by the Engineer or designated representative, is used to transfer the weight (mass) of the top slab to the walls of the box culvert or sewer before the support provided by the forms is removed.

If all test cylinders made for the purpose of form removal have been broken without attaining the required strength, forms shall remain in place for a total of 14 curing days.

The above provisions relative to form removal shall apply only to forms or parts thereof which are constructed to permit removal without disturbing forms or falsework required to be left in place for a longer period on other portions of the structure.

Remove all metal appliances used inside forms for alignment shall be removed to a depth of at least ½ in. (13 mm) from the concrete surface. The appliances shall be manufactured to allow the removal without undue chipping or spalling of the concrete, and so that it leaves a smooth opening in the concrete surface when removed. Rods, bolts and ties shall not be burned-off.

Backfilling against walls of Type I or Type II cement shall not take place for a minimum of 7 days. Backfilling against walls of Type III cement shall not take place until the cylinder compressive strength has reached 3000 psi (20.7 MPa) or the wall has cured for 5 days.

All forms and falsework shall be removed unless indicated otherwise on the drawings.

410S.25 Defective Work * See Modifications for additional information

Any defective work discovered after the forms have been removed shall be repaired as soon as possible in accordance with "Finishing Exposed Surfaces", below.

If the surface of the concrete is bulged, uneven or shows excess honeycombing or form marks, which in the opinion of the Engineer or designated representative, cannot be repaired satisfactorily, the entire section shall be removed and replaced at the expense of the Contractor.

410S.26 Finishing Exposed Surfaces

A. Ordinary Surface Finish

An Ordinary Surface Finish shall be applied to all concrete surfaces either as a final finish or preparatory to a higher grade or class of finish. Higher grades and classes of finish shall conform to Item No. 411S, "Surface Finishes for Concrete". Where neither a grade or class of finish is specified, an Ordinary Surface Finish only, will be required.

Ordinary Surface Finish shall be provided as follows:

1. After form removal, all porous, honeycombed areas and spalled areas shall be corrected by chipping away all loose or broken material to sound concrete.
2. Feathered edges shall be eliminated by saw-cutting and chipping spalled areas to a depth at least $\frac{1}{2}$ in. (13 mm) deep perpendicular to the surface. Shallow cavities shall be repaired using a latex adhesive grout, cement mortar or epoxy grout approved by the Engineer or designated representative. If judged repairable by the Engineer or designated representative, large defective areas shall be corrected using concrete or other material approved by the Engineer or designated representative.
3. Holes and spalls caused by removal of form ties, etc., shall be cleaned and filled with latex adhesive grout, cement mortar or epoxy grout approved by the Engineer or designated representative. Only the holes shall be filled. The patch shall not be blended with the surrounding concrete. On surfaces to receive a rub finish in accordance with Standard Specification Item No. 411S, "Surface Finishes for Concrete" the exposed parts of metal chairs shall be chipped out to a depth of $\frac{1}{2}$ inch (13 mm) and the surface repaired.
4. All fins, runs, drips or mortar that will be exposed shall be removed from surfaces. Form marks and chamfer edges shall be smoothed by grinding and/or dry rubbing.
5. Grease, oil, dirt, curing compound, etc., shall be removed from surfaces requiring a higher grade of finish. Discolorations resulting from spillage or splashing of asphalt, paint or other similar material shall be removed.
6. Repairs shall be dense, well bonded and properly cured and when made on surfaces, which remain exposed and do not require a higher finish, shall be finished to blend with the surrounding concrete.

Unless otherwise indicated on the drawings Ordinary Surface Finish shall be the final finish for the following exposed surfaces:

1. inside and top of inlets,
2. inside and top of manholes,
3. inside of sewer appurtenances,
4. inside of culvert barrels,
5. bottom of bridge decks between beams or girders,
6. vertical and bottom surfaces of interior concrete beams or girders.

B. Rubbed Finish

In general, the following areas shall require a rubbed finish and shall receive a first and second rubbing:

1. The top, exterior and roadway fascia of curbs and parapet walls.
2. All concrete surfaces of railing.
3. The exterior vertical fascia of slab spans, rigid frames, arches and box girders.
4. The outside and bottom surfaces of fascia beams or girders (except precast concrete beams).

5. The underside of overhanging slabs to the point of juncture of the supporting beams.
6. All vertical surfaces of piers, columns, bent caps, abutments, wing walls and retaining walls which are exposed to view after all backfill and embankments is placed.
7. Exposed formed surfaces of inlet and outlet structures on culverts, transition structures, headwalls and inlets.
8. Such other surfaces specified elsewhere to receive a rubbed finish and such additional surfaces required by the Engineer or designated representative to receive a rubbed finish.

After removal of forms and as soon as the mortar used in pointing has set sufficiently, surfaces to be rubbed shall be wet with a brush and given a first surface rubbing with a medium coarse carborundum stone. This rubbing shall be done before the concrete has cured more than 48 hours.

The second rubbing shall present a cleaned uniform appearance free from drip marks and discoloration. It shall be given with a No.30 carborundum stone or an abrasive of equal quality.

If the Contractor elects to use epoxy paint in lieu of the second rubbings the Contractor may do so upon approval of the Engineer or designated representative.

C. Special Surface Finishes

Striated, exposed aggregate and other special surface finishes shall conform to Standard Specification Item No. 411S, "Surface Finishes for Concrete" and/or with the requirements indicated on the drawings.

410S.27 Measurement and Payment

No direct measurement or payment will be made for the work to be done or the equipment to be furnished under this item, but shall be included in the unit price bid for the item of construction in which this item is used.

End

SPECIFIC CROSS REFERENCE MATERIALS	
Standard Specification Item 410S, "Concrete Structures"	

City of Austin Standard Specification Items

Designation	Description
Item No. 360S	Concrete Pavement
Item No. 401S	Structural Excavation and Backfill
Item No. 403S	Concrete for Structures
Item No. 406S	Reinforcing Steel
Item No. 411S	Surface Finishes for Concrete
Item No. 413S	Cleaning and/or Sealing Joints and Cracks (PC Concrete)
Item No. 425S	Prestressed Concrete Structures

U.S. Department of Commerce Voluntary Product Standard, PS 1

American Concrete Institute

Designation	Description
ACI 347	Guide to Formwork for Concrete

American Society for Testing and Materials (ASTM)

Designation	Description
ASTM D-994	Preformed Expansion Joint Filler for Concrete (bituminous Type)
ASTM D-1751	Prefprmed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D-1752	Prefprmed Sponge Rubber and Cork Expansion Joint Fillers for Concrete Paving and Structural Construction

Texas Department of Transportation: Departmental Material Specifications

Designation	Description
DMS-4640	Chemical Admixtures for Concrete
DMS-4650	Hydraulic Cement Concrete Curing Materials and Evaporation Retardants"
DMS-6100	Epoxy and Adhesives
DMS-6160	Waterstops, Nylon Reinforced Neoprene Sheet, and Elastomeric Pads
DMS-6310	Joint Materials and Fillers

Texas Department of Transportation: Manual of Testing Procedures

Designation	Description
Tex-436-A	Measurement of Texture Depth by the Sand Patch Method
Tex-440-A	Initial Time-of-Set of Fresh Concrete

RELATED CROSS REFERENCE MATERIALS
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Standard Specification Item 410S, "Concrete Structures"

American Society for Testing and Materials, ASTM

Designation	Description
A 36/A 36M	Carbon Structural Steel
A 82	Steel Wire, Plain, for Concrete Reinforcement
A 185	Steel Welded Wire Fabric, Plain, for Concrete Reinforcement
A 496	Steel Wire, Deformed, for Concrete Reinforcement
A 497	Steel Welded Wire Fabric, Deformed, for Concrete Reinforcement
A 615/A 615M	Deformed and Plain Billet-steel Bars for Concrete Reinforcement
A 675/A 675M	Steel Bars, Carbon, Hot-Wrought, Special Quality, Mechanical Properties
A 706/A 706M	Low- Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
A 775/A 775M	Epoxy-Coated Reinforcing Steel Bars
A 884/A 884M	Epoxy-Coated Steel Wire and Welded Wire Fabric For Reinforcement
A 934/A 934M	Epoxy-Coated Prefabricated Reinforcing Steel Bars
A 996/A 996M	Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement
D3963/D3963M	Fabrication and Jobsite Handling of Epoxy-coated Reinforcing Steel Bars

Texas Department of Transportation: Manual of Testing Procedures

Designation	Description
Tex-739-I	Sampling and Testing Epoxy Coated Reinforcing Steel

City of Austin Standard (Details)

Designation	Description
Standard 406S-1	Reinforced Steel Tolerances

Texas Department of Transportation: Departmental Material Specifications

Designation	Description
DMS 8130	Epoxy Powder Coating for Reinforcing Steel

City of Austin Standard Specification Items

Designation	Description
Item No. 404S	Pneumatically Placed Concrete
Item No. 407S	Fibrous Concrete
Item No. 414S	Concrete Retaining Walls
Item No. 420S	Drilled Shaft Foundations

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

Designation	Description
Item No. 360	Concrete Pavement
Item No. 420	Concrete Structures
Item No. 421	Hydraulic Cement Concrete
Item No. 422	Reinforced Concrete Slab
Item No. 423	Retaining Walls
Item No. 440	Reinforcing Steels