

UPC

Document No: Technical Specifications

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1 Introduction

The purpose of this annex is to give an idea of which are the main specifications that lead the design and building of our project and to explain which are those procedures that need to be followed.

Since the job will be executed in Texas, United States, the specifications that need to be followed are the ones that the Texas Department of Transportation impose and the general specification for all the bridges of the United States.

The AASHTO has all the specifications for the design loads to be considered, different types of rebar and concrete, load combination, etc.

Apart from this specification, every single state in the States has his own specification. The Texas one is called Standard Specifications for Construction and Maintenance of Highways, streets and bridges. This specification is known as Maroon Book. In this Maroon book we can find all the different disciplines that the construction world have:

- Earthwork and Landscape
- Subgrade treatments and base
- Surface courses and pavements
- Structures
- Miscellaneous
- Lighting, Signing, Marking and Signals
- Maintenance

Each one of these chapters it is divided in the different items that the category has. Also each item is divided in five different parts:

1. Description of the item
2. Equipment required for the construction of the item
3. Construction: Restrictions and requirements for the construction of the item.
4. Measurement: It tells basically in which unit is measured.
5. Payment: It tells if the item is a measure or a plan item.

For our project we will focus on the bridge items, the earthwork needed for the excavation and other miscellaneous elements as reflectors, signs, electric elements, etc.

Attachement 1: Used items of the Specification Maroon Book

In this attachment we are going to expose the following items of the Maroon Book that are the ones used in the project:

- Item 110: Excavation
- Item 416: Drilled Shafts Foundations
- Item 420: Concrete Structures
- Item 422: Reinforced Concrete Slab
- Item 423: Retaining Walls
- Item 425: Precast Prestressed Concrete Structural Members
- Item 450: Railing
- Item 454: Bridge Expansion Joints
- Item 496: Removing Structures
- Item 512: Portable Concrete Traffic Barrier
- Item 536: Concrete medians and directional Islands
- Item 540: Metal Beam Guard Fence
- Item 552: Wire Fence
- Item 644: Small Roadside Sign Supports and Assemblies
- Item 666: Reflectorized Pavement Markings
- Item 681: Temporary traffic signs



**STANDARD
SPECIFICATIONS
FOR CONSTRUCTION
AND MAINTENANCE OF
HIGHWAYS, STREETS,
AND BRIDGES**

**Adopted by the
Texas Department of Transportation**

June 1, 2004

106.1 to 110.2

ITEM 106

OBLITERATING ABANDONED ROAD

106.1. Description. Obliterate designated sections of abandoned road.

106.2. Construction. Strip and windrow existing topsoil before shaping operations. Remove asphaltic pavement in accordance with applicable item. Remove material designated as salvageable in accordance with applicable items. Remove abandoned structures unless otherwise shown on the plans. Scarify and mix the abandoned roadbed with soil and blade to produce a smooth, uniform appearance. Fill, cut, and shape the designated sections of the abandoned road to blend into the surrounding terrain. Eliminate ditches except where needed to facilitate drainage. Cover disturbed areas with topsoil after shaping operations to facilitate establishment of vegetation.

106.3. Measurement. This Item will be measured by the 100-ft. station along the baseline of the abandoned roadway.

106.4. Payment. The work performed in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Obliterating Abandoned Road." This price is full compensation for salvaging and replacing topsoil; stockpiling or disposal of materials; removal of abandoned structures; scarifying, mixing, and shaping abandoned road; furnishing and operating equipment, and labor, tools, and incidentals.

ITEM 110

EXCAVATION

110.1. Description. Excavate areas as shown on the plans or as directed. Remove materials encountered to the lines, grades, and typical sections shown on the plans and cross-sections.

110.2. Construction. Accept ownership of unsuitable or excess material and dispose of material in accordance with local, state, and federal regulations at locations outside the right of way.

Maintain drainage in the excavated area to avoid damage to the roadway section. Correct any damage to the subgrade caused by weather, at no additional cost to the Department.

Shape slopes to avoid loosening material below or outside the proposed grades. Remove and dispose of slides as directed.

110.3 to 110.4

- A. Rock Cuts.** Excavate to finish subgrade. Manipulate and compact subgrade in accordance with Article 132.3.D, "Compaction Methods," unless excavation is to clean homogenous rock at finish subgrade elevation. If excavation extends below finish subgrade, use approved embankment material compacted in accordance with Article 132.3.D to replace undercut material at no additional cost.
- B. Earth Cuts.** Excavate to finish subgrade. In areas where base or pavement structure will be placed on subgrade, scarify subgrade to a uniform depth at least 6 in. below finish subgrade elevation. Manipulate and compact subgrade in accordance with Article 132.3.D, "Compaction Methods."
- If unsuitable material is encountered below subgrade elevations, take corrective measures as directed. Drying required deeper than 6 in. below subgrade elevation will be paid for in accordance with Article 9.4, "Payment for Extra Work." Excavation and replacement of unsuitable material below subgrade elevations will be performed and paid for in accordance with the applicable bid items. However, if Item 132, "Embankment," is not included in the Contract, payment for replacement of unsuitable material will be paid for in accordance with Article 9.4.
- C. Subgrade Tolerances.** For turnkey construction, excavate to within 1/2 in. in cross-section and 1/2 in. in 16 ft. measured longitudinally. For staged construction, excavate to within 0.1 ft. in cross-section and 0.1 ft. in 16 ft. measured longitudinally.

110.3. Measurement. This Item will be measured by the cubic yard in its original position as computed by the method of average end areas.

This is a plans quantity measurement Item. The quantity to be paid is the quantity shown in the proposal unless modified by Article 9.2, "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.

Limits of measurement for excavation in retaining wall areas will be as shown on the plans.

Shrinkage or swelling factors will not be considered in determining the calculated quantities.

110.4. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Excavation (Roadway)," "Excavation (Channel)," "Excavation (Special)," or "Excavation (Roadway

110.4 to 112.3

and Channel).” This price is full compensation for authorized excavation; drying; undercutting subgrade and reworking or replacing the undercut material in rock cuts; hauling; disposal of material not used elsewhere on the project; scarification and compaction; and equipment, labor, materials, tools, and incidentals.

When a slide not due to the Contractor’s negligence or operation occurs, payments for removal and disposal of the slide material will be in accordance with Article 9.4, “Payment for Extra Work.” Excavation in backfill areas of retaining walls will not be measured or paid for directly but will be subsidiary to pertinent Items.

ITEM 112 SUBGRADE WIDENING

112.1. Description. Widen the existing subgrade in accordance with the typical sections.

112.2. Materials. Furnish water in accordance with Article 204.2, “Materials.”

112.3. Construction.

- A. Preparation of Embankment.** Scarify to a depth of at least 6 in. into existing adjacent embankment slopes before fill is placed.
- B. Pavement Structure Removal.** Remove material along the edge of the existing pavement. Provide a smooth vertical cut unless otherwise shown on the plans. Conform to the typical sections for the limits of removal unless directed otherwise. Accept ownership of excess material not used in the construction of the subgrade widening. Dispose of excess material in accordance with federal, state, and local regulations.
- C. Widening.** In cut sections, remove material and move to fill sections within the project. Use material from cut sections for embankment. In fill sections, place the material in successive lifts to the line and grades shown on the typical sections. Provide additional embankment in accordance with the applicable bid item or Article 9.4, “Payment for Extra Work,” if all excavation has been performed and additional embankment is required to complete the work.
- D. Compaction.** Compact the widened subgrade in accordance with Article 132.3, “Construction.”

409.5 to 416.2

Test-loaded piling and associated anchor piling will be paid for as provided in Item 405, "Foundation Test Load" except that any test load ordered by the Engineer that is not provided for in the Contract will be paid for in accordance with Article 9.4, "Payment for Extra Work."

- A. Concrete Piling.** The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Prestressed Concrete Piling" or "Prestressed Concrete Test Piling" of the size specified.
- B. Buildups.** An additional payment for each completed authorized buildup splice for both regular and test piling, regardless of buildup length, will be made at a price equal to 10 times the unit price bid for "Prestressed Concrete Piling." Where piling is broken back for constructing buildups, payment for the breakback is included in the payment for buildups.
- C. Cutoffs.** Payment for cutoff lengths of both regular piling and test piling will be made at a price equal to 1/2 the unit price bid per foot for "Prestressed Concrete Piling."

ITEM 416

DRILLED SHAFT FOUNDATIONS

416.1. Description. Construct foundations consisting of reinforced or non-reinforced concrete drilled shafts with or without bell footings.

416.2. Materials. Use materials that meet the requirements of the following Items:

- Item 421, "Hydraulic Cement Concrete"
- Item 440, "Reinforcing Steel"
- Item 448, "Structural Field Welding."

Unless otherwise shown on the plans, use concrete for drilled shafts that meets the requirements of Table 1.

**Table 1
Concrete for Drilled Shafts**

Drilled Shaft Type	Concrete
Non-reinforced	Class A
Reinforced	Class C
Slurry and underwater concrete placement	Class SS

416.2 to 416.2

Use coarse aggregate Grade 4, 5, or 6 for drilled shaft concrete in reinforced drilled shafts. Grade 2 or 3 may be used if the shaft is dry and reinforcing steel has a 5-in. minimum clear spacing.

Use a water-reducing, retarding admixture in accordance with DMS-4640, "Chemical Admixtures for Concrete," in all concrete when using casing that will be pulled or when placing shafts underwater or under slurry.

Use concrete with slump that meets the requirements of Table 2 as determined by Tex-415-A.

**Table 2
Slump Requirements**

Placement Type	Minimum Acceptable Placement Slump, in.	Recommended Design and Placement Slump, in.	Maximum Acceptable Placement Slump, in.
Dry	5-1/2	6-1/2	7-1/2
Underwater and under slurry	7	8	9

When casing is to be pulled or when concrete is to be placed underwater or under slurry, perform a slump loss test in accordance with Tex-430-A before beginning work. Provide concrete that will maintain a slump of at least 4 in. throughout the entire anticipated time of concrete placement. Time of concrete placement is described in Sections 416.3.F, "Concrete," and 416.3.G, "Additional Requirements for Slurry Displacement or Underwater Concrete Placement Methods." Note the temperature of the concrete mix at the beginning of the slump loss test. If concrete temperature at the time of placement into the drilled shaft is more than 10° higher than the slump loss test temperature, do not place the concrete. Use ice or other concrete cooling ingredients to lower concrete temperature, or run additional slump loss tests at the higher temperatures. Slump loss testing will be waived if anticipated time of concrete placement is less than 90 minutes.

Use drilling slurry that meets the requirements of Table 3, as determined by Tex-130-E.

416.3 to 416.3

**Table 3
Slurry Requirements**

Before Introduction into the Excavation		Sampled from the Bottom of the Excavation before Concreting		
Specific Gravity	Sand Content	Specific Gravity	Viscosity (seconds)	Sand Content
≤ 1.10	≤ 1%	≤ 1.15	≤ 45	≤ 6%

Use mineral slurry consisting of processed bentonite or attapulgite clays mixed with clean fresh water. Do not use PHPA (partially hydrolized polyacrylamide) polymeric slurry or any other fluid composed primarily of a polymer solution.

Before placing concrete, sample slurry from the bottom of the hole, and test it in accordance with Tex-130-E. Use a pump or air lift to remove slurry that does not meet the requirements of Table 3 while adding fresh clean slurry to the top of the hole to maintain the slurry level. Continue this operation until the slurry sampled from the bottom of the hole meets the requirements.

416.3. Construction. Place the shaft to within the following tolerances.

- Vertical plumbness – 1 in. per 10 ft. of depth.
- Center of shaft located under column – 1 in. of horizontal plan position.
- Center of shaft located under footing – 3 in. of horizontal plan position.

Complete the embankment at bridge ends before installing drilled shafts that pass through the fill. Refer to Item 423, “Retaining Walls,” for provisions for drilled shafts passing through the structural volume of retaining walls.

A. Excavation. The plans indicate the expected depths and elevations for encountering satisfactory bearing material. Excavate as required for the shafts and bell footings through all materials encountered to the dimensions and elevations shown on the plans or required by the site conditions. Removal of man-made obstructions not shown on the plans will be paid for in accordance with Article 9.4, “Payment for Extra Work.” If satisfactory founding material is not encountered at plan elevation, adjust the bottom of the shaft or alter the foundation, as determined by the Engineer, to satisfactorily comply with design requirements. Blasting is not allowed for excavations.

If caving conditions are encountered, stop drilling and adopt a construction method that stabilizes the shaft walls.

Do not excavate a shaft within 2 shaft diameters (clear) of an open shaft excavation, or one in which concrete has been placed in the preceding 24 hours.

Dispose of material excavated from shafts and bells and not incorporated into the finished project. Dispose of excavated material in accordance with the plans and with federal, state, and local laws.

Provide suitable access, lighting, and equipment for proper inspection of the completed excavation and for checking the dimensions and alignment of shafts and bell excavation.

- B. Core Holes.** If directed, take cores to determine the character of the supporting materials. Use a method that will result in recovery of an intact sample adequate for judging the character of the founding material. Such cores should be at least 5 ft. deeper than the proposed founding grade or a depth equal to the diameter of the shaft, whichever is greater. Take these cores when the excavation is approximately complete.
- C. Casing.** Use casing when necessary to prevent caving of the material or to exclude ground water. Provide casing with an outside diameter not less than the specified diameter of the shaft. Use casing strong enough to withstand handling stresses and pressures of concrete and of the surrounding earth or water, and that is watertight, smooth, clean, and free of accumulations of hardened concrete.

Drill the portion of the shaft below the casing as close as possible to the specified shaft diameter. The portion of shaft below the casing may be as much as 2 in. smaller than the specified shaft diameter.

Use construction methods that result in a minimal amount of disturbed soil being trapped outside the casing. This does not apply to temporary undersized casings used to protect workers inside shafts or to drilled shafts designed for point bearing only.

Do not leave any casing in place unless authorized or shown on the plans. Do not extract casing until after placing the concrete to an appropriate level. Maintain sufficient concrete in the casing at all times to counteract soil and water pressure. Before and during concrete placement, rotate or move the casing up or down a few inches if necessary to facilitate extraction of the casing.
- D. Requirements for Slurry Displacement Method.** Unless otherwise shown on the plans, the slurry displacement method may be used to construct drilled shafts. Use this method to support the sides of the

416.3 to 416.3

excavation with processed mineral slurry that is then displaced by concrete to form a continuous concrete shaft.

Do not use casing other than surface casing. Do not use surface casing longer than 20 ft. without approval. Do not extract the surface casing until after placing the concrete.

For slurry mixed at the project site, pre-mix it in a reservoir of sufficient capacity to fill the excavation and for recovery of the slurry during concrete placement. Do not mix slurry in the shaft excavation or other hole. Allow adequate time for hydration of the slurry prior to introduction into the excavation.

During and after drilling maintain a head of slurry in the shaft excavation at or near ground level or higher as necessary to counteract ground water pressure.

Just before placing reinforcing steel, use an air lift or proper size cleanout bucket to remove any material that may have fallen from the sides of the excavation or accumulated on the bottom after the completion of drilling. Use a cleanout bucket if material is too large to be picked up with an air lift.

If concrete placement is not started within 4 hours of the completion of the shaft excavation, reprocess the hole with the auger as directed. Then clean the bottom with an air lift or cleanout bucket, and check the slurry at the bottom of the hole for compliance with the slurry requirements of Article 416.2, "Materials."

If the slurry forms a gel before concrete placement, agitate the congealed slurry to liquefaction just before concrete placement and whenever directed.

Recover and dispose of all slurry as approved by the Engineer, and in accordance with all federal, state, and local laws. Do not discharge slurry into or in close proximity to streams or other bodies of water.

- E. Reinforcing Steel.** Completely assemble the cage of reinforcing steel, and place it as a unit immediately before concrete placement. The cage consists of longitudinal bars and lateral reinforcement (spiral reinforcement, lateral ties, or horizontal bands). If overhead obstacles prevent placement of the cage as a single unit, connect individual segments with couplers or by lapping steel as approved.

If the shaft is lengthened beyond plan length, extend the reinforcing steel cage as follows, unless directed otherwise:

- For shafts supporting structures other than bridges, extend the cage to the bottom.

- For bridge shafts with plan lengths of less than 25 ft., extend the cage to 25 ft. or to the bottom, whichever is shorter.
- For bridge shafts with plan lengths at least 25 ft. that are lengthened less than 33% of plan length, extending the cage is not necessary.
- For bridge shafts with plan lengths at least 25 ft. that are lengthened more than 33% of plan length, extend the cage as directed.

If the cage does not reach the bottom of the shaft, it may be suspended, or a portion of the longitudinal steel may be extended to support the cage on the bottom of the shaft. Bars used to extend or support the cage may be lap spliced or welded by a qualified welder. Place the extension at the bottom of the shaft.

If using spiral reinforcement, tie it to the longitudinal bars at a spacing of at most 24 in., or as required for a stable cage. Do not weld lateral reinforcement to longitudinal bars unless otherwise shown on the plans.

Center the reinforcing steel cage in the excavation using approved centering devices. Use enough devices to hold the cage in position along its entire length. Do not use square concrete spacer blocks in cased shafts.

Support or hold down the cage to control vertical displacement during concrete placement or extraction of the casing. Use support that is concentric with the cage to prevent racking and distortion of the steel.

Check the elevation of the top of the steel cage before and after concrete placement or after casing extraction when casing is used. Downward movement of the steel up to 6 in. per 20 ft. of shaft length and upward movement of the steel up to 6 in. total are acceptable.

Maintain the minimum length of steel required for lap with column steel. Use dowel bars if the proper lap length is provided both into the shaft and into the column. Locate and tie all dowel bars into the cage before placing concrete or insert dowel bars into fresh, workable concrete.

Locate and tie anchor bolts when required prior to placement of concrete. Use templates or other devices to assure accurate placement of anchor bolts.

- F. Concrete.** Perform all work in accordance with requirements of Item 420, "Concrete Structures." Mass concrete placement requirements do not apply to drilled shafts.

Form portions of drilled shaft that project above natural ground.

416.3 to 416.3

Remove loose material and accumulated seep water from the bottom of the excavation before placing concrete. If water cannot be removed, place concrete using underwater placement methods.

Place concrete as soon as possible after all excavation is complete and reinforcing steel is placed. Provide workable concrete that does not require vibrating or rodding. Vibrate formed portions of drilled shafts.

Place concrete continuously for the entire length of the shaft. For dry shafts of 24 in. or smaller diameter, limit free fall of concrete to 25 ft. Use a suitable tube or tremie to prevent segregation of materials. Use a tube or tremie in sections to provide proper discharge and to permit raising as the placement progresses. For dry shafts over 24 in. diameter, concrete can be allowed to free fall an unlimited distance if it does not strike the reinforcing cage or sides of the hole during placement. When free fall is used, provide a hopper with a minimum 3-ft.-long drop tube at the top of the shaft to direct concrete vertically down the center of the shaft. Do not use a shovel or other means to simply deflect the concrete discharge from the truck.

For cased shafts, maintain a sufficient head of concrete at all times above the bottom of the casing to overcome hydrostatic pressure.

Extract casing at a slow, uniform rate with the pull in line with the axis of the shaft. Monitor the concrete level in the casing during extraction. Stop the extraction and add concrete to the casing as required to ensure a completely full hole upon casing removal. The elapsed time from the mixing of the first concrete placed into the cased portion of the shaft until the completion of extraction of the casing must not exceed the time for which the concrete maintains a slump of over 4 in.

in accordance with Article 416.2, "Materials." If the elapsed time is exceeded, modify the concrete mix, the construction procedures, or both for subsequent shafts.

Cure the top surface and treat any construction joint area in accordance with Item 420, "Concrete Structures."

- G. Additional Requirements for Slurry Displacement or Underwater Concrete Placement Methods.** Place concrete on the same day that the shaft is excavated and as soon as possible after all excavation is complete and reinforcing steel is placed. Use an air lift or cleanout bucket of the proper size to clean the bottom of the excavation prior to placing the reinforcing steel cage and concrete. Place concrete through a closed tremie or pump it to the bottom of the excavation. Initially seal the tremie or pump line to positively separate the concrete from the slurry or water. Place concrete continuously from the beginning of

416.4 to 416.4

placement until the shaft is completed. If using a tremie, keep it full of concrete and well submerged in the previously placed concrete at all times. Raise the tremie as necessary to maintain the free flow of concrete and the stability of any casing used. If using a pump, keep the discharge tube submerged in the previously placed concrete at all times. Place additional concrete to ensure the removal of any contaminated concrete at the top of the shaft. At the completion of the pour, allow the top portion of concrete to flush completely from the hole until there is no evidence of slurry or water contamination. Do not attempt to remove this concrete with shovels, pumps or other means. Level the top of shaft with hand tools as necessary.

Use a sump or other approved method to channel displaced fluid and concrete away from the shaft excavation. Recover slurry and dispose of it as approved. Do not discharge displaced fluids into or in close proximity to streams or other bodies of water. For pours over water, provide a collar or other means of capturing slurry and the top portion of concrete flushed from the shaft.

If concrete placement is interrupted due to withdrawal of the submerged end of the tremie or pump discharge tube before completion, remove the tube, reseal it at the bottom, penetrate with the tube into the concrete already placed by at least 5 ft., and recharge it before continuing.

The elapsed time from the mixing of the first concrete placed until the completion of concrete placement, including extraction of the casing, must not exceed the time for which the concrete maintains a slump of over 4 in. in accordance with Article 416.2, "Materials." If the elapsed time is exceeded, modify the concrete mix, the construction procedures, or both for subsequent shafts.

- H. Test Load.** If required, test load shafts in accordance with Item 405, "Foundation Test Load."

416.4. Measurement.

- A. Drilled Shaft.** Drilled shaft foundations will be measured by the foot to the bottom of the shaft.
- 1. Interior Bents and Piers.** Shafts will be measured from a point approximately 6 in. below the finished earthwork elevation at the center of each shaft, unless specific elevations or dimensions are indicated on the plans or unless the Engineer directs otherwise to meet unusual conditions. The bent height shown on the plans is for

416.5 to 416.5

estimating purposes only and does not control the top-of-shaft measurement.

2. **Abutment Bents and Retaining Walls.** Shafts will be measured from the bottom of footing or cap elevation.
3. **Other Non-Bridge Structures.** Shafts will be measured from the top of the shaft.

B. Bell Footing. Bell footings will be measured by the cubic yard of concrete outside of the plan dimensions of the shaft. Bell footings are a plans quantity measurement item. The quantity to be paid is the quantity shown in the proposal, unless modified by Article 9.2, "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.

C. Core Hole. Core holes will be measured by each core hole drilled.

416.5. Payment. The unit prices bid for the various classifications of drilled shafts and bell footings will be full compensation for excavation; furnishing, placing, and removing casing; furnishing, processing, and recovering slurry; pumping; furnishing, and placing reinforcing steel; furnishing and placing concrete, including additional concrete required to fill an oversize casing or oversize excavation; conducting slump loss tests; backfilling; disposing of cuttings and slurry; and materials, tools, equipment, labor, and incidentals.

When the bottom of a drilled shaft is placed at an elevation below plan grade, no direct payment will be made for extra reinforcement placed to support the cage. The extra reinforcement will be considered subsidiary to the price bid per foot of shaft. No extra payment will be made for casings left in place.

No payment will be made for "Bell Footing" or "Drilled Shaft" until the concrete has been placed.

A. Drilled Shaft. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Drilled Shaft" or "Drilled Shaft (Non-reinforced)" or "Drilled Shaft (Sign Mounts)" or "Drilled Shaft (High Mast Pole)" of the specified diameter, subject to the limitations for overruns authorized by the Engineer given in Section 416.5.A.1, "Overrun."

1. **Overrun.** Payment for individual completed shaft lengths up to and including 5 ft. in excess of the maximum plan length shaft, as

416.5 to 416.5

defined in Section 416.5.A.2, "Maximum Plan Length Shaft," will be made at the unit price bid per foot of the specified diameter.

Payment for the portion of individual completed shaft length in excess of 5 ft. and up to and including 15 ft. more than the maximum plan length shaft, as defined in this Item, will be made at a unit price equal to 115% of the unit price bid per foot of the specified diameter.

Payment for that portion of individual completed shaft length in excess of 15 ft. more than the maximum plan length shaft, as defined in Section 416.5.A.2, will be made at a unit price equal to 125% of the unit price bid per foot of the specified diameter.

2. **Maximum Plan Length Shaft.** Payment described above is subject to the following provisions for extra depth drilling:
 - For bridge structures, the maximum plan length shaft is the maximum length shaft, regardless of diameter, for any drilled shaft on that specific bridge.
 - For retaining walls, the maximum plan length shaft is the maximum length shaft, regardless of diameter, for any drilled shaft on that specific retaining wall.
 - For overhead sign structures, the maximum plan length shaft is the maximum length shaft, regardless of diameter, for any overhead sign structures included in the contract.
 - For high mast illumination poles, the maximum plan length shaft is the maximum length shaft, regardless of diameter, for any high mast illumination pole included in the contract.
- B. **Bell Footing.** Bell footings constructed to specified dimensions will be paid for at the unit price bid per cubic yard for "Bell Footings." The quantity to be paid for will be the quantity shown on the plans, unless revised by the Engineer in accordance with "Measurement."
- C. **Core Hole.** Core holes will be paid at \$125 each.

420.1 to 420.2

ITEM 420
CONCRETE STRUCTURES

420.1. Description. Construct concrete structures.

420.2. Materials.

- A. Concrete.** Provide concrete conforming to Item 421, “Hydraulic Cement Concrete.” For each type of structure or unit, provide the class of concrete shown on the plans or in pertinent governing specifications.
- B. Grout or Mortar.** Provide grout or mortar conforming to Section 421.2.F, “Mortar and Grout.”
- C. Latex.** Provide an acrylic-polymer latex admixture (acrylic resin emulsion per DMS-4640, “Chemical Admixtures for Concrete”) suitable for producing polymer-modified concrete or mortar. Do not allow latex to freeze.
- D. Reinforcing Steel.** Provide reinforcing steel conforming to Item 440, “Reinforcing Steel.”
- E. Expansion Joint Material.** Provide materials that conform to the requirements of DMS-6310, “Joint Sealants and Fillers”:
 - Provide preformed fiber expansion joint material that conforms to the dimensions shown on the plans. Provide preformed bituminous fiber material unless otherwise specified.
 - Provide a Class 4, 5, or 7 low-modulus silicone sealant unless otherwise directed.
 - Provide asphalt board that conforms to dimensions shown on the plans.
 - Provide re-bonded neoprene filler that conforms to the dimensions shown on the plans.
- F. Waterstop.** Provide rubber or polyvinyl chloride (PVC) waterstops that conform to DMS-6160, “Waterstops, Nylon Reinforced Neoprene Sheet, and Elastomeric Pads,” unless otherwise shown on the plans.
- G. Evaporation Retardants.** Provide evaporation retardants that conform to the requirements of DMS-4650, “Hydraulic Cement Concrete Curing Materials and Evaporation Retardants.”
- H. Curing Materials.** Provide membrane curing compounds that conform to the requirements of DMS-4650, “Hydraulic Cement Concrete Curing Materials and Evaporation Retardants.”

Provide cotton mats that consist of a filling material of cotton “bat” or “bats” (at least 12 oz. per square yard) completely covered with unsized cloth (at least 6 oz. per square yard) stitched longitudinally with continuous parallel rows of stitching spaced at less than 4 in., or tuft both longitudinally and transversely at intervals less than 3 in. Provide cotton mats that are free from tears and in good general condition. Provide a flap at least 6 in. wide consisting of 2 thicknesses of the covering and extending along 1 side of the mat.

Provide polyethylene sheeting that is at least 4 mils thick and free from visible defects. Provide only clear or opaque white sheeting when the ambient temperature during curing exceeds 60°F or when applicable to control temperature during mass pours.

Provide burlap-polyethylene mats made from burlap impregnated on 1 side with a film of opaque white pigmented polyethylene, free from visible defects. Provide laminated mats that 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 are free of visible defects.

- I. **Epoxy.** Unless otherwise specified, provide epoxy materials that conform to DMS-6100, “Epoxy and Adhesives.”

420.3. Equipment.

- A. **Fogging Equipment.** Use fogging equipment that can apply water in a fine mist, not a spray. Produce the fog using equipment that pumps water or water and air under high pressure through a suitable atomizing nozzle. Use hand-held mechanical equipment portable enough to use in the direction of any prevailing wind and adaptable for intermittent use to prevent excessive wetting of the concrete.
- B. **Transporting and Placing Equipment.** Use appropriate transporting and placing equipment such as buckets, chutes, buggies, belt conveyors, pumps, or other equipment as necessary. Do not transport or convey concrete through equipment made of aluminum. Use carts with pneumatic tires for carting or wheeling concrete over newly placed slabs.

Use tremies to control the fall of concrete or for underwater placement. Use tremies that are watertight and of large enough diameter to allow the placement of the concrete but less than 14 in. in diameter. For underwater placements, construct the tremie so that the bottom can be sealed and opened once the tremie has been fully charged with concrete.

420.3 to 420.3

Use pumps with lines at least 5 in. I.D. where Grade 2 or smaller coarse aggregate is used, and at least 8 in. I.D. for Grade 1 coarse aggregate.

- C. **Vibrators.** Use immersion-type vibrators for consolidation of concrete. Provide at least 1 standby vibrator for emergency use.
- D. **Screeds and Work Bridges for Bridge Slabs.** For bridge slabs use a self-propelled transverse screed or a mechanical longitudinal screed. Use transverse screeds that are able to follow the skew of the bridge for skews greater than 15° unless otherwise approved. Equip transverse screeds with a pan float. Manually operated screeding equipment may be used if approved for top slabs of culverts, small placements, or unusual conditions. Use screeds that are rigid and heavy enough to hold true to shape and have sufficient adjustments to provide for the required camber or section. Equip the screeds, except those of the roller drum type, with metal cutting edges.

For bridge slabs, use sufficient work bridges for finishing operations. Mount a carpet drag to a work bridge or a moveable support system that can vary the area of carpet in contact with the concrete. Use carpet pieces long enough to cover the entire width of the placement. Splice or overlap the carpet as necessary. Ensure that enough carpet is in contact longitudinally with the concrete being placed to provide the desired surface finish. Use artificial grass-type carpeting having a molded polyethylene pile face with a blade length between 5/8 and 1 in. and with a minimum weight of 70 oz. per square yard. Ensure that the carpet has a strong, durable backing not subject to rot and that the facing is adequately bonded to the backing to withstand the intended use. A burlap drag, attached to the pan float on a transverse screed, may be used instead of the carpet drag.

- E. **Temperature Recording Equipment.** For mass concrete operations or as otherwise specified, use strip chart temperature recording devices, recording maturity meters in accordance with Tex-426-A, or other approved devices that are accurate to within $\pm 2^{\circ}\text{F}$ within the range of 32 to 212°F.
- F. **Artificial Heating Equipment.** Use artificial heating equipment as necessary for maintaining the concrete temperatures as specified in Section 420.4.G.11, "Placing Concrete in Cold Weather."
- G. **Sawing Equipment.** Use sawing equipment capable of cutting grooves in completed bridge slabs and top slabs of direct-traffic culverts. Provide grooves that are 1/8 to 3/16 in. deep and nominally 1/8 in. wide. Groove spacing may range from 5/8 to 1 in. Use sawing

equipment capable of cutting grooves in hardened concrete to within 18 in. of the barrier rail or curb.

- H. Spraying Equipment.** Use mechanically powered pressure sprayers, either air or airless, with appropriate atomizing nozzles for the application of membrane curing. Mechanically driven spraying equipment, adaptable to the rail system used by the screeds, may be used for applying membrane curing to bridge slabs. If approved, use hand-pressurized spray equipment equipped with 2 or 3 fan-spray nozzles. Ensure that the spray from each nozzle overlaps the spray from adjacent nozzles by approximately 50%.
- I. Concrete Testing Equipment.** Provide testing equipment for use by the Engineer in accordance with Section 421.3.C, "Testing Equipment."

420.4. Construction. Before starting work, obtain approval for proposed construction methods. Approval of construction methods and equipment does not relieve the Contractor's responsibility for safety or correctness of methods, adequacy of equipment, or completion of work in full accordance with the Contract.

Unless otherwise shown on the plans, it is the Contractor's option to perform testing on structural concrete (structural classes of concrete are identified in Table 5 of Section 421.4.A, "Classification and Mix Design") to determine the in-situ strength to address the schedule restrictions in Section 420.4.A, "Schedule Restrictions." The Engineer may require the Contractor to perform this testing for concrete placed in cold weather. For Contractor-performed testing, make enough test specimens to ensure that strength requirements are met for the operations listed in Section 420.4.A. Make at least 1 set of test specimens for each element cast each day. Cure these specimens under the same conditions as the portion of the structure involved for all stages of construction. Ensure safe handling, curing, and storage of all test specimens. Provide testing personnel, and sample and test the hardened concrete in accordance with Section 421.4.G, "Sampling and Testing of Concrete." The maturity method, Tex-426-A, may be used for in-situ strength determination for schedule restrictions if approved. Coring will not be allowed for in-situ strength determination for schedule restrictions. Provide the Engineer the opportunity to witness all testing operations. Report all test results to the Engineer.

If the Contractor does not wish to perform schedule restriction testing, the Engineer's 7-day lab-cured tests, performed in accordance with Section 421.4.G.5, "Adequacy and Acceptance of Concrete," will be used

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for schedule restriction determinations. The Engineer may require additional time for strength gain to account for field curing conditions such as cold weather.

A. Schedule Restrictions. Unless otherwise shown on the plans, construct and open completed structures to traffic with the following limitations:

- 1. Setting Forms.** Attain at least 2,500 psi compressive strength before erecting forms on concrete footings supported by piling or drilled shafts, or on individual drilled shafts. Erect forms on spread footings and culvert footings after the footing concrete has aged at least 2 curing days as defined in Section 420.4.J, "Curing Concrete." Place concrete only after the forms and reinforcing steel have been inspected by the Engineer.

Support tie beam or cap forms by falsework on previously placed tie beams only if the tie beam concrete has attained a compressive strength of 2,500 psi and the member is properly supported to eliminate stresses not provided for in the design. Maintain curing as required until completion of the curing period.

Place superstructure forms or falsework on the substructure only if the substructure concrete has attained a compressive strength of 3,000 psi.

- 2. Removal of Forms and Falsework.** Keep in place weight-supporting forms and falsework for bridge components and culvert slabs until the concrete has attained a compressive strength of 2,500 psi in accordance with Section 420.4.K, "Removal of Forms and Falsework." Keep all forms for mass placements defined in Section 420.4.G.14, "Mass Placements," in place for 4 days following concrete placement.
- 3. Placement of Superstructure Members.** Do not place superstructure members before the substructure concrete has attained a compressive strength of 3,000 psi.
- 4. Longitudinal Screeding of Bridge Slabs.** Place a longitudinal screed directly on previously placed concrete slabs to check and grade an adjacent slab only after the previously placed slab has aged at least 24 hr. Place and screed the concrete after the previously placed slabs have aged at least 48 hr. Maintain curing of the previously placed slabs during placement.
- 5. Staged Placement of Bridge Slabs on Continuous Steel Units.** When staged placement of a slab is required, ensure that the previously placed concrete attains a compressive strength of

3,000 psi before placing the next stage placement. Multiple stages may be placed in a single day if approved.

6. **Storage of Materials on the Structure.** Obtain approval to store materials on completed portions of a structure once a compressive strength of 3,000 psi has been attained. Maintain proper curing if materials will be stored on structures before completion of curing.
7. **Placement of Equipment and Machinery.** Do not place erection equipment or machinery on the structure until the concrete has attained the design strength specified in Section 421.4.A, "Classification and Mix Design," unless otherwise approved.
8. **Carting of Concrete.** Once the concrete has attained a compressive strength of 3,000 psi, it may be carted, wheeled, or pumped over completed slabs. Maintain curing during these operations.
9. **Placing Bridge Rails.** Reinforcing steel and concrete for bridge rails may be placed on bridge slabs once the slab concrete has attained a compressive strength of 3,000 psi. If slipforming methods are used for railing concrete, ensure the slab concrete has attained its design strength specified in Section 421.4.A, "Classification and Mix Design," before placing railing concrete.
10. **Opening to Construction Traffic.** Bridges and direct-traffic culverts may be opened to all construction traffic when the design strength specified in Section 421.4.A, "Classification and Mix Design," has been attained if curing is maintained.
11. **Opening to Full Traffic.** Bridges and direct-traffic culverts may be opened to the traveling public when the design strength specified in Section 421.4.A, "Classification and Mix Design," has been attained for all structural elements including railing subject to impact from traffic, when curing has been completed for all slabs, and when the concrete surface treatment has been applied in accordance with Item 428, "Concrete Surface Treatment." Obtain approval before opening bridges and direct-traffic culverts to the traveling public. Other noncritical structural and nonstructural concrete may be opened for service upon the completion of curing unless otherwise specified or directed.
12. **Post-Tensioned Construction.** For structural elements designed to be post-tensioned ensure that strength requirements on the plans are met for stressing and staged loading of structural elements.

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13. Backfilling. Backfill in accordance with Section 400.3.C, “Backfill.”

- B. Plans for Falsework and Forms.** Submit 2 copies of plans for falsework and forms for piers, superstructure spans over 20 ft. long, bracing systems for girders when the overhang exceeds 3 ft. 6 in., and bridge widening details. Submit similar plans for other units of the structure as directed. Show all essential details of proposed forms, falsework, and bracing. Have a licensed professional engineer design, seal, and sign these plans. Department approval is not required, but the Department reserves the right to request modifications to the plans. The Contractor is responsible for the adequacy of these plans.
- C. Falsework.** Design and construct falsework to carry the maximum anticipated loads safely, including wind loads, and to provide the necessary rigidity. Submit details in accordance with Section 420.4.B, “Plans for Falsework and Forms.”

Design job-fabricated falsework assuming a weight of 150 pcf for concrete, and include a liveload allowance of 50 psf of horizontal surface of the form. Do not exceed 125% of the allowable stresses used by the Department for the design of structures.

For commercially produced structural units used in falsework, do not exceed the manufacturer’s maximum allowable working loads for moment and shear or end reaction. Include a liveload allowance of 35 psf of horizontal form surface in determining the maximum allowable working load for commercially produced structural units.

Provide timber that is sound, in good condition, and free from defects that would impair its strength. Provide timber that meets or exceeds the species, size, and grade requirements in the submitted falsework plans.

Provide wedges made of hardwood or metal in pairs to adjust falsework to desired elevations to ensure even bearing. Do not use wedges to compensate for incorrectly cut bearing surfaces.

Use sills or grillages that are large enough to support the superimposed load without settlement. Take precautions to prevent settling of the supporting material unless the sills or grillages are founded on solid rock, shale, or other hard materials.

Place falsework that cannot be founded on a satisfactory spread footing on piling or drilled shafts with enough bearing capacity to support the superimposed load without settlement. Drive falsework piling to the required resistance determined by the applicable formula in Item 404,

“Driving Piling.” Design drilled shafts for falsework to carry the superimposed load using both skin friction and point bearing.

Weld in conformance with Item 448, “Structural Field Welding.”

Securely brace each falsework bent to provide the stiffness required, and securely fasten the bracing to each pile or column it crosses.

Remove falsework when it is no longer required or as indicated on the submitted falsework plan. Pull or cut off foundations for falsework at least 2 ft. below finished ground level. Completely remove falsework, piling, or drilled shafts in a stream, lake, or bay to the approved limits to prevent obstruction to the waterway.

D. Forms. Submit formwork plans in accordance with Section 420.4.B, “Plans for Falsework and Forms.”

1. General. Except where otherwise specified or permitted, provide forms of either timber or metal.

Design forms for the pressure exerted by a liquid weighing 150 pcf. Take the rate of concrete placement into consideration in determining the depth of the equivalent liquid. Include a liveload allowance of 50 psf of horizontal surface for job-fabricated forms. Do not exceed 125% of the allowable stresses used by the Department for the design of structures.

For commercially produced structural units used for forms, do not exceed the manufacturer’s maximum allowable working loads for moment and shear or end reaction. Include a liveload allowance of 35 psf of horizontal form surface in determining the maximum allowable working load for commercially produced structural units.

Provide steel forms for round columns unless otherwise approved. Refer to Item 427, “Surface Finishes for Concrete,” for additional requirements for off-the-form finishes.

Provide commercial form liners for imprinting a pattern or texture on the concrete surface as shown on the plans and specified in Section 427.4.B.2.d, “Form Liner Finish.”

Provide forming systems that are practically mortar-tight, rigidly braced, and strong enough to prevent bulging between supports, and maintain them to the proper line and grade during concrete placement. Maintain forms in a manner that prevents warping and shrinkage. Do not allow offsets at form joints to exceed 1/16 in.

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For forms to be left in place, use only material that is inert, nonbiodegradable, and nonabsorptive.

Attachment of forms or screed supports for bridge slabs to steel I-beams or girders may be by welding subject to the following requirements:

- Do not weld to tension flanges or to areas indicated on the plans.
- Weld in accordance with Item 448, "Structural Field Welding."

Take into account:

- deflections due to cast-in-place slab concrete and railing shown in the dead load deflection diagram in the setting of slab forms,
- differential beam or girder deflections due to skew angles and the use of certain stay-in-place slab forming systems, and
- deflection of the forming system due to the wet concrete.

For bridge approach slabs, securely stake forms to line and grade and maintain in position. Rigidly attach inside forms for curbs to the outside forms.

Construct all forms to permit their removal without marring or damaging the concrete. Clean all forms and footing areas of any extraneous matter before placing concrete. Provide openings in forms if needed for the removal of laitance or foreign matter

Treat the facing of all forms with bond-breaking coating of composition that will not discolor or injuriously affect the concrete surface. Take care to prevent coating of the reinforcing steel.

Complete all preparatory work before requesting permission to place concrete.

If the forms show signs of bulging or sagging at any stage of the placement, cease placement and remove the portion of the concrete causing this condition immediately if necessary. Reset the forms and securely brace them against further movement before continuing the placement.

2. **Timber Forms.** Provide properly seasoned good-quality lumber that is free from imperfections that would affect its strength or impair the finished surface of the concrete. Provide timber or lumber that meets or exceeds the requirements for species and grade in the submitted formwork plans.

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Maintain forms or form lumber that will be reused so that it stays clean and in good condition. Do not use any lumber that is split, warped, bulged, or marred or that has defects that will produce inferior work, and promptly remove such lumber from the work.

Provide form lining for all formed surfaces except:

- the inside of culvert barrels, inlets, manholes, and box girders;
- the bottom of bridge slabs 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 or by plywood.

Provide form lining of an approved type such as masonite or plywood. Do not provide thin membrane sheeting such as polyethylene sheets for form lining.

Use plywood at least 3/4 in. thick. Place the grain of the face plies on plywood forms parallel to the span between the supporting studs or joists unless otherwise indicated on the submitted form drawings.

Use plywood for forming surfaces that remain exposed that meets the requirements for B-B Plyform Class I or Class II Exterior of the U.S. Department of Commerce Voluntary Product Standard PS 1.

Space studs and joists so that the facing form material remains in true alignment under the imposed loads.

Space wales closely enough to hold forms securely to the designated lines, scabbed at least 4 ft. on each side of joints to provide continuity. Place a row of wales near the bottom of each placement.

Place facing material with parallel and square joints, securely fastened to supporting studs.

For surfaces exposed to view and receiving only an ordinary surface finish as defined in Section 420.4.M, "Ordinary Surface Finish," place forms with the form panels symmetrical (long dimensions set in the same direction). Make horizontal joints continuous.

Make molding for chamfer strips or other uses of materials of a grade that will not split when nailed and that can be maintained to a true line without warping. Dress wood molding on all faces. Unless otherwise shown on the plans, fill forms at all sharp corners

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and edges with triangular chamfer strips measuring 3/4 in. on the sides.

To hold forms in place, use metal form ties of an approved type or a satisfactory substitute of a type that permits ease of removal of the metal. Cut back wire ties at least 1/2 in. from the face of the concrete.

Use devices to hold metal ties in place that are able to develop the strength of the tie and adjust to allow for proper alignment.

Entirely remove metal and wooden spreaders that separate the forms as the concrete is being placed.

Provide adequate clean-out openings for narrow walls and other locations where access to the bottom of the forms is not readily attainable.

- 3. Metal Forms.** Requirements for timber forms regarding design, mortar-tightness, filleted corners, beveled projections, bracing, alignment, removal, reuse, and wetting also apply to metal forms except that metal forms do not require lining unless specifically noted on the plans.

Use form metal thick enough to maintain the true shape without warping or bulging. Countersink all bolt and rivet heads on the facing sides. Design clamps, pins, or other connecting devices to hold the forms rigidly together and to allow removal without damage to the concrete. Use metal forms that present a smooth surface and that line up properly. Keep metal free from rust, grease, and other foreign materials.

- 4. Form Supports for Overhang Slabs.** Form supports that transmit a horizontal force to a steel girder or beam or to a prestressed concrete beam are permitted provided a satisfactory structural analysis has been made of the effect on the girder or beam as indicated in the submitted formwork plans.

When overhang brackets are used on prestressed concrete beam spans with slab overhangs not exceeding 3 ft 6 in., use beam bracing as indicated in the plans. For spans with overhangs exceeding this amount, use additional support for the outside beams regardless of the type of beam used. Submit details of the proposed bracing system in accordance with Section 420.4.B, "Plans for Falsework and Forms."

Punch or drill holes full size in the webs of steel members for support of overhang brackets, or torch-cut them to 1/4 in. under

size and ream them full size. Do not burn the holes full size. Leave the holes open unless otherwise shown on the plans. Never fill the holes by welding.

E. Drains. Install and construct weep holes and roadway drains as shown on the plans.

F. Placing Reinforcement. Place reinforcement as provided in Item 440, "Reinforcing Steel." Do not weld reinforcing steel supports to I-beams or girders or to reinforcing steel except where shown on the plans.

Place post-tensioning ducts in accordance with the approved prestressing details and in accordance with Item 426, "Prestressing." Keep ducts free of obstructions until all post-tensioning operations are complete.

G. Placing Concrete. Give the Engineer sufficient advance notice before placing concrete in any unit of the structure to permit the inspection of forms, reinforcing steel placement, and other preparations.

Follow the sequence of placing concrete shown on the plans or specified.

Do not place concrete 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, place concrete in early morning or at night or adjust the placement schedule for more favorable weather. Consult the evaporation rate nomograph in the Portland Cement Association's *Design and Control of Concrete Mixtures* for shrinkage cracking potential. When mixing, placing, and finishing concrete in non-daylight hours, adequately illuminate the entire placement site as approved.

If changes in weather conditions require protective measures after work starts, furnish adequate shelter to protect the concrete against damage from rainfall or from freezing temperatures as outlined in this Item. Continue operations during rainfall only if approved. Use protective coverings for the material stockpiles. Cover aggregate stockpiles only to the extent necessary to control the moisture conditions in the aggregates.

Allow at least 1 curing day after the concrete has achieved initial set before placing strain on projecting reinforcement to prevent damage to the concrete.

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1. **Placing Temperature.** Place concrete according to the following temperature limits for the classes of concrete defined in Section 421.4.A, “Classification and Mix Design”:
 - Place Class C, F, H, K, or SS concrete only when its temperature at time of placement is between 50 and 95°F. Increase the minimum placement temperature to 60°F if ground-granulated blast furnace (GGBF) slag is used in the concrete.
 - When used in a bridge slab or in the top slab of a direct-traffic culvert, place Class CO, DC, or S concrete only when its temperature at the time of placement is between 50 and 85°F. Increase the minimum placement temperature to 60°F if GGBF slag is used in the concrete. The maximum temperature increases to 95°F if these classes are used for other applications.
 - Place Class A, B, and D concrete only when its temperature at the time of placement is greater than 50°F.
 - Place mass concrete, defined by Section 420.4.G.14, “Mass Placements,” only when its temperature at the time of placement is between 50 and 75°F.
2. **Transporting Time.** Place concrete delivered in agitating trucks within 60 min. after batching. Place concrete delivered in non-agitating equipment within 45 min. after batching. Revise the concrete mix design as necessary for hot weather or other conditions that contribute to quick setting of the concrete. Submit for approval a plan to demonstrate that these time limitations can be extended while ensuring the concrete can be properly placed, consolidated, and finished without the use of additional water.
3. **Workability of Concrete.** Place concrete with a slump as specified in Section 421.4.A.5, “Slump.” Concrete that exceeds the maximum slump will be rejected. Water may be added to the concrete before discharging any concrete from the truck to adjust for low slump provided that the maximum mix design water–cement ratio is not exceeded. After introduction of any additional water or chemical admixtures, mix concrete in accordance with Section 421.4.E, “Mixing and Delivering Concrete.” Do not add water or chemical admixtures after any concrete has been discharged.
4. **Transporting Concrete.** Use a method and equipment capable of maintaining the rate of placement shown on the plans or required by this Item to transport concrete to the forms. Transport concrete

by buckets, chutes, buggies, belt conveyors, pumps, or other methods.

Protect concrete transported by conveyors from sun and wind to prevent loss of slump and workability. Shade or wrap with wet burlap pipes through which concrete is pumped as necessary to prevent loss of slump and workability.

Arrange and use chutes, troughs, conveyors, or pipes so that the concrete ingredients will not be separated. When necessary to prevent segregation, terminate such equipment in vertical downspouts. Extend open troughs and chutes, if necessary, down inside the forms or through holes left in the forms.

Keep all transporting equipment clean and free from hardened concrete coatings. Discharge water used for cleaning clear of the concrete.

5. **Preparation of Surfaces.** Thoroughly wet all forms, prestressed concrete panels, T-beams, and concrete box beams on which concrete is to be placed before placing concrete on them. Remove any remaining puddles of excess water before placing concrete. Provide surfaces that are in a moist, saturated surface-dry condition when concrete is placed on them.

Ensure that the subgrade or foundation is moist before placing concrete for bridge approach slabs or other concrete placed on grade. Lightly sprinkle the subgrade if dry.

6. **Expansion Joints.** Construct joints and devices to provide for expansion and contraction in accordance with plan details and the requirements of this Section and Item 454, "Bridge Expansion Joints."

Prevent bridging of concrete or mortar around expansion joint material in bearings and expansion joints.

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

When the plans show a Type A joint, provide preformed fiber joint material in the vertical joints of the roadway slab, curb, median, or sidewalk, and fill the top 1 in. with the specified joint sealing material unless noted otherwise. Install the sealer in accordance

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with Item 438, “Cleaning and Sealing Joints and Cracks (Rigid Pavement and Bridge Decks),” and the manufacturer’s recommendations.

Use light wire or nails to anchor any preformed fiber joint material to the concrete on 1 side of the joint.

Ensure that finished joints conform to the plan details with the concrete sections completely separated by the specified opening or joint material.

Remove all concrete within the joint opening soon after form removal and again where necessary after surface finishing to ensure full effectiveness of the expansion joint.

7. **Construction Joints.** A construction joint is the joint formed by placing plastic concrete in direct contact with concrete that has attained its initial set. Monolithic placement means that the manner and sequence of concrete placing does not create a construction joint.

Make construction joints of the type and at the locations shown on the plans. Do not make joints in bridge slabs not shown on the plans unless approved. Additional joints in other members are not permitted without approval. Place authorized additional joints using details equivalent to those shown on the plans for joints in similar locations.

Unless otherwise required, make construction joints square and normal to the forms. Use bulkheads in the forms for all vertical joints.

Thoroughly roughen the top surface of a concrete placement terminating at a horizontal construction joint as soon as practical after initial set is attained.

Thoroughly clean the hardened concrete surface of all loose material, laitance, dirt, and foreign matter, and saturate it with water. Remove all free water and moisten the surface before concrete or bonding grout is placed against it.

Draw forms tight against the existing concrete to avoid mortar loss and offsets at joints.

Coat the joint surface with bonding mortar, grout, epoxy, or other material as indicated in the plans or other Items. Provide Type V epoxy per DMS-6100, “Epoxies and Adhesives,” for bonding fresh concrete to hardened concrete. Place the bonding epoxy on a clean,

dry surface, and place the fresh concrete while the epoxy is still tacky. Place bonding mortar or grout on a surface that is saturated surface-dry, and place the concrete before the bonding mortar or grout dries. Place other bonding agents in accordance with the manufacturer's recommendations.

- 8. Handling and Placing.** Minimize segregation of the concrete and displacement of the reinforcement when handling and placing concrete. Produce a uniform dense compact mass.

Do not allow concrete to free-fall more than 5 ft. except in the case of drilled shafts, thin walls such as in culverts, or as allowed by other Items. Remove any hardened concrete splatter ahead of the plastic concrete.

Fill each part of the forms by depositing concrete as near its final position as possible. Do not deposit large quantities at 1 point and run or work the concrete along the forms.

Deposit concrete in the forms in layers of suitable depth but not more than 36 in. deep unless otherwise permitted.

Avoid cold joints in a monolithic placement. Sequence successive layers or adjacent portions of concrete so that they can be vibrated into a homogeneous mass with the previously placed concrete before it sets. When re-vibration of the concrete is shown on the plans, allow at most 1 hr. to elapse between adjacent or successive placements of concrete except as otherwise allowed by an approved placing procedure. This time limit may be extended by 1/2 hr. if the concrete contains at least a normal dosage of retarding admixture.

Use an approved retarding agent to control stress cracks and cold joints in placements where differential settlement and setting time may induce cracking.

- 9. Consolidation.** Carefully consolidate concrete and flush mortar to the form surfaces with immersion type vibrators. Do not use vibrators that operate by attachment to forms or reinforcement except where approved on steel forms.

Vibrate the concrete immediately after deposit. Systematically space points of vibration to ensure complete consolidation and thorough working of the concrete around the reinforcement, embedded fixtures, and into the corners and angles of the forms. Insert the vibrator vertically where possible except for slabs where it may be inserted in a sloping or horizontal position. Vibrate the

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entire depth of each lift, allowing the vibrator to penetrate several inches into the preceding lift. Do not use the vibrator to move the concrete to other locations in the forms. Do not drag the vibrator through the concrete. Thoroughly consolidate concrete along construction joints by operating the vibrator along and close to but not against the joint surface. Continue the vibration until the concrete surrounding reinforcements and fixtures is completely consolidated. Hand-spade or rod the concrete if necessary to ensure flushing of mortar to the surface of all forms.

- 10. Installation of Dowels and Anchor Bolts.** Install dowels and anchor bolts by casting them in-place or by grouting with grout, epoxy, or epoxy mortar unless noted otherwise. Form or drill holes for grouting.

Drill holes for anchor bolts to accommodate the bolt embedment required by the plans. Make holes for dowels at least 12 in. deep unless otherwise shown on the plans. When using grout or epoxy mortar, make the diameter of the hole at least twice the dowel or bolt diameter, but the hole need not exceed the dowel or bolt diameter plus 1-1/2 in. When using epoxy, make the hole diameter 1/16 to 1/4 in. greater than the dowel or bolt diameter.

Thoroughly clean holes of all loose material, oil, grease, or other bond-breaking substance, and blow them clean with filtered compressed air. Ensure that holes are in a surface dry condition when epoxy type material is used and in a surface moist condition when hydraulic cement grout is used. Develop and demonstrate for approval a procedure for cleaning and preparing the holes for installation of the dowels and anchor bolts. Completely fill the void between the hole and dowel or bolt with grouting material. Follow exactly the requirements for cleaning outlined in the product specifications for prepackaged systems.

For cast-in-place or grouted systems, provide hydraulic cement grout in accordance with Section 421.2.F, "Mortar and Grout," epoxy, epoxy mortar, or other prepackaged grouts as approved. Provide a Type III epoxy per DMS-6100, "Epoxyes and Adhesives," when neat epoxy is used for anchor bolts or dowels. Provide Type VIII epoxy per DMS-6100 when an epoxy grout is used. Provide grout, epoxy, or epoxy mortar as the binding agent unless otherwise indicated on the plans.

Provide other anchor systems as required in the plans.

11. Placing Concrete in Cold Weather. Protect concrete placed under weather conditions where weather may adversely affect results. Permission given by the Engineer for placing during cold weather does not relieve the Contractor of responsibility for producing concrete equal in quality to that placed under normal conditions. If concrete placed under poor conditions is unsatisfactory, remove and replace it as directed at Contractor's expense.

Do not place concrete in contact with any material coated with frost or having a temperature of 32°F or lower. Do not place concrete when the ambient temperature in the shade is below 40°F and falling unless approved. Concrete may be placed when the ambient temperature in the shade is 35°F and rising or above 40°F.

Provide and install recording thermometers, maturity meters, or other suitable temperature measuring devices to verify that all concrete is effectively protected as follows:

- Maintain the temperature of the top surface of bridge slabs and top slabs of direct-traffic culverts at 50°F or above for 72 hr. from the time of placement and above 40°F for an additional 72 hr.
- Maintain the temperature at all surfaces of concrete in bents, piers, culvert walls, retaining walls, parapets, wingwalls, bottoms of bridge slab or culvert top slabs, and other similar formed concrete at 40°F or above for 72 hr. from the time of placement.
- Maintain the temperature of all other concrete, including the bottom slabs (footings) of culverts, placed on or in the ground above 32°F for 72 hr. from the time of placement.

Use additional covering, insulated forms, or other means and, if necessary, supplement the covering with artificial heating. Avoid applying heat directly to concrete surfaces. Cure as specified in Section 420.4.J, "Curing Concrete," during this period until all requirements for curing have been satisfied.

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

12. Placing Concrete in Hot Weather. Use an approved retarding agent in all concrete for superstructures and top slabs of direct-

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traffic culverts, except concrete containing GGBF slag, when the temperature of the air is above 85°F unless otherwise directed.

Keep the concrete at or below the maximum temperature at time of placement as specified in Section 420.4.G.1, "Placing Temperature." Sprinkle and shade aggregate stockpiles or use ice, liquid nitrogen systems, or other approved methods as necessary to control the concrete temperature.

- 13. Placing Concrete in Water.** Deposit concrete in water only when shown on the plans or with approval. Make forms or cofferdams tight enough to prevent any water current passing through the space in which the concrete is being deposited. Do not pump water during the concrete placing or until the concrete has set for at least 36 hr.

Place the concrete with a tremie or pump, or use another approved method, and do not allow it to fall freely through the water or disturb it after it is placed. Keep the concrete surface approximately level during placement.

Support the tremie or operate the pump so that it can be easily moved horizontally to cover all the work area and vertically to control the concrete flow. Submerge the lower end of the tremie or pump hose in the concrete at all times. Use continuous placing operations until the work is complete.

For concrete to be placed under water, design the concrete mix in accordance with Item 421, "Hydraulic Cement Concrete," with a minimum cement content of 650 lb. per cubic yard. Include an anti-washout admixture in the mix design as necessary to produce a satisfactory finished product.

- 14. Mass Placements.** Mass placements are defined as placements with a least dimension greater than or equal to 5 ft., or designated on the plans. For monolithic mass placements, develop and obtain approval for a plan to ensure the following during the heat dissipation period:
 - the temperature differential between the central core of the placement and the exposed concrete surface does not exceed 35°F and
 - the temperature at the central core of the placement does not exceed 160°F.

Base this plan on the equations given in the Portland Cement Association's *Design and Control of Concrete Mixtures*. Cease all

mass placement operations and revise the plan as necessary if either of the above limitations is exceeded.

Include a combination of the following elements in this plan:

- selection of concrete ingredients including aggregates, gradation, and cement types, to minimize heat of hydration;
- use of ice or other concrete cooling ingredients;
- use of liquid nitrogen dosing systems;
- controlling rate or time of concrete placement;
- use of insulation or supplemental external heat to control heat loss;
- use of supplementary cementing materials; or
- use of a cooling system to control the core temperature.

Furnish and install 2 sets of temperature recording devices, maturity meters, or other approved equivalent devices at designated locations. Use these devices to simultaneously measure the temperature of the concrete at the core and the surface. Maintain temperature control methods for 4 days unless otherwise approved. Maturity meters may not be used to predict strength of mass concrete.

- 15. Placing Concrete in Foundation and Substructure.** Do not place concrete in footings until the depth and character of the foundation has been inspected and permission has been given to proceed.

Placing of concrete footings upon seal concrete is permitted after the cofferdams are free from water and the seal concrete cleaned. Perform any necessary pumping or bailing during the concreting from a suitable sump located outside the forms.

Construct or adjust all temporary wales or braces inside cofferdams as the work proceeds to prevent unauthorized construction joints.

When footings can be placed in a dry excavation without the use of cofferdams, omit forms if approved, and fill the entire excavation with concrete to the elevation of the top of footing.

Place concrete in columns monolithically between construction joints unless otherwise directed. Columns and caps or tie beams supported on them may be placed in the same operation or separately. If placed in the same operation, allow for settlement and shrinkage of the column concrete by placing it to the lower level of the cap or tie beam, and delay placement between 1 and 2 hr. before proceeding with the cap or tie beam placement.

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- 16. Placing Concrete in Box Culverts.** Where the top slab and walls are placed monolithically in culverts more than 4 ft. in clear height, allow between 1 and 2 hr. to elapse before placing the top slab to allow for settlement and shrinkage in the wall concrete.

Accurately finish the footing slab at the proper time to provide a smooth uniform surface. Finish top slabs that carry direct-traffic as specified in this Item. Give top slabs of fill type culverts a float finish.

- 17. Placing Concrete in Superstructure.** Unless otherwise shown on the plans, place simple span bridge slabs without transverse construction joints by using either a self-propelled transverse finishing machine or a mechanical longitudinal screed. For small placements or for unusual conditions such as narrow widening, variable cross-slopes, or transitions, use of manually operated screeding equipment may be permitted. Support the screed adequately on a header or rail system stable enough to withstand the longitudinal or lateral thrust of the equipment. Adjust the profile grade line as necessary to account for variations in beam camber and other factors to obtain the required slab thickness and concrete cover over the slab reinforcement. Set beams and verify their surface elevations in a sufficient number of spans so that when adjustment is necessary, the profile grade line can be adjusted over suitable increments to produce a smooth riding surface. Take dead load deflection into account in setting the grades of headers and rail systems. Use construction joints, when required or permitted for slab placements on steel or prestressed concrete beams, as shown on the plans. Before placing concrete on steel girder or truss spans, release falsework under the spans and swing the spans free on their permanent supports.

Make 1 or more passes with the screed over the bridge slab segment before placing concrete on it to ensure proper operation and maintenance of grades and clearances. Use an approved system of checking to detect any vertical movement of the forms or falsework. Maintain forms for the bottom surface of concrete slabs, girders, and overhangs to the required vertical alignment during concrete placing.

Fog unformed surfaces of slab concrete in bridge slabs and in top slabs of direct-traffic culverts from the time of initial strikeoff of the concrete until finishing is completed and required interim curing is in place. Do not use fogging as a means to add finishing

water, and do not work moisture from the fog spray into the fresh concrete.

For simple spans, retard the concrete only if necessary to complete finishing operations or as required by this Section. When filling curb forms, bring the top of curb and sidewalk section to the correct camber and alignment, and finish them as described in this Item.

- a. Transverse Screeding.** Install rails for transverse finishing machines that are supported from the beams or girders so that the supports may be removed without damage to the slab. Prevent bonding between removable supports and the concrete in an acceptable manner. Do not allow rail support parts that remain embedded in the slab to project above the upper mat of reinforcing steel. Rail or screed supports attached to I-beams or girders are subject to the requirements of this Item. Unless otherwise shown on the plans, for transverse screeding the minimum rate of concrete placement is 30 linear feet of bridge slab per hour. Deposit concrete parallel to the skew of the bridge so that all girders are loaded uniformly along their length. Deposit slab concrete between the exterior beam and the adjacent beam before placing concrete in the overhang portion of the slab. Furnish personnel and equipment capable of placing, finishing, and curing the slab at an acceptable rate to ensure compliance with the specifications. Place concrete in transverse strips. On profile grades greater than 1-1/2%, start placement at the lowest end.
- b. Longitudinal Screeding.** Unless otherwise shown on the plans, use of temporary intermediate headers will be permitted for placements over 50 ft. long if the rate of placement is rapid enough to prevent a cold joint and if these headers are designed for easy removal to permit satisfactory consolidation and finish of the concrete at their locations. Deposit slab concrete between the exterior beam and the adjacent beam before placing concrete in the overhang portion of the slab. Place concrete in longitudinal strips starting at a point in the center of the segment adjacent to 1 side except as this Section indicates, and complete the strip by placing uniformly in both directions toward the ends. For spans on a profile grade of 1-1/2% or more, start placing at the lowest end. Use strips wide enough that the concrete within each strip remains plastic until placement of the adjacent strip. Where monolithic curb

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construction is specified, place the concrete in proper sequence to be monolithic with the adjacent longitudinal strips of the slabs.

- c. **Placements on Continuous Steel Units.** Unless otherwise shown on the plans, place slabs on continuous steel units in a single continuous operation without transverse construction joints using a self-propelled transverse finishing machine or a mechanical longitudinal screed. Retard the initial set of the concrete sufficiently to ensure that concrete remains plastic in at least 3 spans immediately preceding the slab being placed. Use construction joints, when required for slab placements on steel beams or girders, as shown on the plans. When staged placement of a slab is required in the plans, ensure that the previously placed concrete attains a compressive strength of 3,000 psi before placing the next stage concrete. Multiple stages may be placed in a single day if approved. Where plans permit staged placing without specifying a particular order of placement, use an approved placing sequence that will not overstress any of the supporting members.
- d. **Slab and Girder Units.** Unless otherwise shown on the plans, place girders, slab, and curbs of slab and girder spans monolithically. Fill concrete girder stems first, and place the slab concrete within the time limits specified in this Item. If using a transverse screed, place concrete in the stems for a short distance and then place the concrete in transverse strips. If using a longitudinal screed, fill the outside girder stem first, beginning at the low end or side, and continue placement in longitudinal strips.

- H. **Treatment and Finishing of Horizontal Surfaces Other Than Bridge Slabs.** Strike off to grade and finish all unformed upper surfaces. Do not use mortar topping for surfaces constructed under this Section.

After the concrete has been struck off, float the surface with a suitable float. Give bridge sidewalks a wood float or broom finish, or stripe them with a brush.

Slightly slope the tops of caps and piers between bearing areas from the center toward the edge, and slope the tops of abutment and transition bent caps from the backwall to the edge, as directed, so that water drains from the surface. Give the concrete a smooth trowel finish. Construct bearing areas for steel units in accordance with

Section 441.3.K.5, "Bearing and Anchorage Devices." Give the bearing area under the expansion ends of concrete slabs and slab and girder spans a steel-trowel finish to the exact grades required. Give bearing areas under elastomeric bearing pads or nonreinforced bearing seat buildups a textured, wood float finish. Do not allow the bearing area to vary from a level plane more than 1/16 in. in all directions.

Cast bearing seat buildups or pedestals for concrete units integrally with the cap or with a construction joint. Provide a latex-based mortar, an epoxy mortar, or an approved proprietary bearing mortar for bearing seat buildups cast with a construction joint. Mix mortars in accordance with the manufacturer's recommendations. Construct pedestals of Class C concrete, reinforced as shown on the plans or as indicated in Figure 1 and Figure 2.

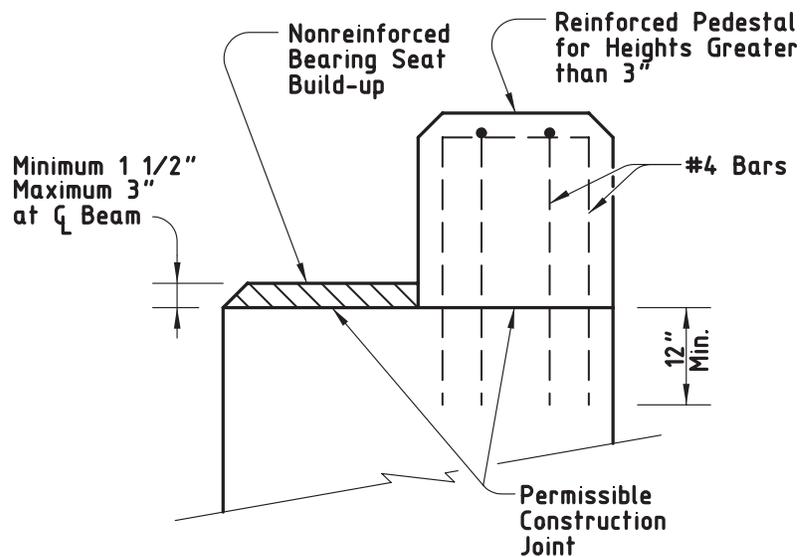


Figure 1
Section through bearing seat buildups.

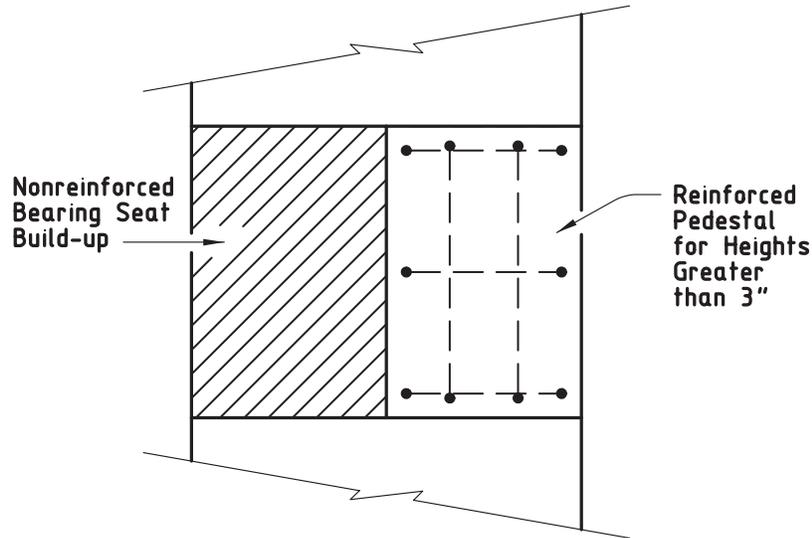


Figure 2
Plan view of bearing seat buildups.

I. Finish of Bridge Slabs. Provide camber for specified vertical curvature and transverse slopes.

For concrete flat slab and concrete slab and girder spans cast in place on falsework, provide additional camber to offset the initial and final deflections of the span as indicated in the plans. For concrete slab and girder spans using pan forms, provide camber of approximately 3/8 in. for 30-ft. spans and 1/2 in. for 40-ft. spans to offset initial and final deflections unless otherwise directed. For concrete flat slab and concrete slab and girder spans not using pan forms, when dead load deflection is not shown on the plans, provide a camber of 1/8 in. per 10 ft. of span length but no more than 1/2 in.

Provide a camber of 1/4 in. in addition to deflection for slabs without vertical curvature on steel or prestressed concrete beams.

Use work bridges or other suitable facilities to perform all finishing operations and to provide access, if necessary, for the Engineer to check measurements for slab thickness and reinforcement cover.

As soon as the concrete has been placed and vibrated in a section wide enough to permit working, level, strike off, and screed the surface, carrying a slight excess of concrete ahead of the screed to fill all low spots.

Move longitudinal screeds 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. Move transverse screeds longitudinally approximately 1/5 of the drum length for each complete out-and-back pass of the carriage.

Screed the surface of the concrete enough times and at intervals to produce a uniform surface true to grade and free of voids.

Work the screeded surface to a smooth finish with a long-handled wood or metal float or hand-float it from work bridges over the slab. Floating may not be necessary if the pan float attached to a transverse screed produces an acceptable finish. Avoid overworking the surface of the concrete. Avoid overuse of finish water.

Perform sufficient checks, witnessed by the Engineer, with a long-handled 16-ft. straightedge on the plastic concrete to ensure that the final surface will be within specified tolerances. Make the check with the straightedge parallel to the centerline. Lap each pass half over the preceding pass. Remove all high spots, and fill and float all depressions over 1/16 in. deep with fresh concrete. Continue checking and floating until the surface is true to grade and free of depressions, high spots, voids, or rough spots. Fill screed-rail support holes with concrete, and finish them to match the top of the slab.

Finish the concrete surface to a uniform texture using a carpet drag, burlap drag, or broom finish. Finish the surface to a smooth sandy texture without blemishes, marks, or scratches deeper than 1/16 in. Apply the surface texturing using a work bridge or platform immediately after completing the straightedge checks. Draw the carpet or burlap drag 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.

Coat the concrete surface immediately after the carpet or burlap drag, or broom finish with a single application of evaporation retardant at a rate recommended by the manufacturer. Do not allow more than 10 min. to elapse between the texturing at any location and application of evaporation retardant. The evaporation retardant may be applied

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using the same work bridge used for surface texturing. Do not work the concrete surface once the evaporation retardant has been applied.

Apply interim and final curing in accordance with Section 420.4.J, "Curing Concrete."

The Contractor is responsible for the ride quality of the finished bridge slab. The Engineer will use a 10-ft. straightedge (1/8 in. in 10 ft.) to verify ride quality and to determine locations where corrections are needed. If the Engineer determines that the ride quality is unacceptable, submit a plan for approval to produce a ride of acceptable quality. Make all corrections for ride before saw-cutting grooves.

Saw-cut grooves in the hardened concrete of bridge slabs, bridge approach slabs, and direct-traffic culverts to produce the final texturing after completion of the required curing period. Cut grooves perpendicular to the structure centerline. Cut grooves continuously across the slab to within 18 in. of the barrier rail, curb, or median divider. At skewed metal expansion joints in bridge slabs, adjust groove cutting by using narrow-width cutting heads so that all grooves end within 6 in. of the joint, measured perpendicular to the centerline of the metal joint. Leave no ungrooved surface wider than 6 in. adjacent to either side of the joint. Ensure that 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, is 1 in. Cut grooves continuously across construction joints or other joints in the concrete that are less than 1/2 in. wide. Apply the same procedure described above where barrier rails, curbs, or median dividers are not parallel to the structure centerline to maintain the 18-in. maximum dimension from the end of the grooves to the gutter line. Cut grooves continuously across formed concrete joints.

When the plans call for a concrete overlay to be placed on the slab (new construction) or on prestressed concrete box beams or other precast elements, give a carpet drag, burlap drag, or broom finish to all concrete surfaces to be overlaid. Saw-grooving is not required in this case. Provide an average texture depth for the finish of approximately 0.035 in. with no individual test falling below 0.020 in., unless otherwise shown on the plans, when tested in accordance with Tex-436-A. If the texture depth falls below what is intended, revise finishing procedures to produce the desired texture.

When the plans require an asphalt seal, with or without overlay, on the slab (new construction), on prestressed concrete box beams, or on other precast elements, give all concrete surfaces to be covered a lightly

textured broom or carpet drag finish. Provide an average texture depth of approximately 0.025 in. when tested in accordance with Tex-436-A.

- J. Curing Concrete.** Obtain approval of the proposed curing methods, equipment, and materials before placing concrete. The Engineer may require the same curing methods for like portions of a single structure. Inadequate curing or facilities may delay all concrete placement on the job until remedial action is taken.

A curing day is a calendar day when the temperature, taken in the shade away from artificial heat, is above 50°F for at least 19 hr. or, on colder days if the temperature of all surfaces of the concrete is maintained above 40°F, for the entire 24 hr. The required curing period begins when all concrete has attained its initial set. Tex-440-A may be used to determine when the concrete has attained its initial set.

Cure all concrete for 4 consecutive days except as noted in Table 1.

Table 1
Exceptions to 4-Day Curing

Description	Type of Cement	Required Curing Days
Upper surfaces of bridge slabs, top slab of direct-traffic culverts, and concrete overlays	I or III	8
	II or I/II	10
	All types with supplementary cementing materials	10
Concrete piling buildups	All	6

For upper surfaces of bridge slabs, bridge approach slabs, median and sidewalk slabs, and culvert top slabs constructed using Class S concrete, apply interim curing using a Type 1-D curing compound as soon as possible after application of the evaporation retardant and after the water sheen has disappeared, but no more than 45 min. after application of the evaporation retardant. Apply membrane interim curing using a work bridge or other approved apparatus to ensure a uniform application. Water-cure for final curing in accordance with this Section, starting as soon as possible without damaging the surface finish. Maintain the water curing for the duration noted in Table 1. Place polyethylene sheeting, burlap-polyethylene blankets, laminated mats, or insulating curing mats in direct contact with the slab when the air temperature is expected to drop below 40°F during the first 72 hr. of the curing period. Weigh down these curing materials with dry mats to maintain direct contact with the concrete and to provide insulation

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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 drops below the specified curing temperature. Avoid applying heat directly to concrete surfaces.

For the top surface of any concrete unit upon which concrete is to be placed and bonded at a later interval (stub walls, risers, etc.) and other superstructure concrete (curbs, wingwalls, parapet walls, etc.), use only water curing in accordance with this Section.

Cure all other concrete as specified in the pertinent Items. Use the following methods for curing concrete, subject to the requirements of this Item.

1. **Form Curing.** When forms are left in intimate contact with the concrete, other curing methods are not required except for exposed surfaces and for cold weather protection. If forms are removed before the 4-day required curing period, use another approved curing method.
2. **Water Curing.** Keep all exposed surfaces of the concrete wet continuously for the required curing time. Use water curing that meets the requirements for concrete mixing water in Section 421.2.D, "Water." Do not use seawater or water that stains or leaves an unsightly residue.
 - a. **Wet Mats.** Keep the concrete continuously wet by maintaining wet cotton mats in direct contact with the concrete for the required curing time. If needed, place damp burlap blankets made from 9-oz. stock on the damp concrete surface for temporary protection before applying cotton mats. Then place the dry mats and wet them immediately after they are placed. Weight the mats adequately to provide continuous contact with all concrete. Cover surfaces that cannot be cured by direct contact with mats, forming an enclosure well anchored to the forms or ground so that outside air cannot enter the enclosure. Provide sufficient moisture inside the enclosure to keep all surfaces of the concrete wet.
 - b. **Water Spray.** Overlap sprays or sprinklers to keep all unformed surfaces continuously wet.
 - c. **Ponding.** Cover the surfaces with at least 2 in. of clean granular material, kept wet at all times, or at least 1 in. deep water. Use a dam to retain the water or saturated granular material.

- 3. Membrane Curing.** Unless otherwise shown on the plans, choose either Type 1-D or Type 2 membrane-curing compound when membrane curing is permitted. Type 1-D (Resin Base Only) is required for interim curing bridge slabs and top slabs of direct-traffic culverts and all other surfaces that require a higher grade of surface finish. For substructure concrete provide only 1 type of curing compound on any 1 structure.

Apply membrane curing just after free moisture has disappeared at a rate of approximately 180 sq. ft. per gallon. Do not spray curing compound on projecting reinforcing steel or concrete that will later form a construction joint. Do not apply membrane curing to dry surfaces. Dampen formed surfaces and surfaces that have been given a first rub so that they are moist at the time of application of the membrane.

When membrane is used for complete curing, leave the film unbroken for the minimum curing period specified. Correct damaged membrane immediately by reapplication of membrane. Polyethylene sheeting, burlap-polyethylene mats, or laminated mats in close contact with the concrete surfaces are equivalent to membrane curing.

- K. Removal of Forms and Falsework.** Unless otherwise directed, forms for vertical surfaces may be removed after the concrete has aged 12 hr. after initial set provided the removal can be done without damage to the concrete. Keep forms for mass placements, defined in Section 420.4.G.14, "Mass Placements," in place for 4 days following concrete placement.

Remove forms for inside curb faces and for bridge rails whenever removal can be done without damage to the curb or railing.

Leave in place weight-supporting forms and falsework spanning more than 1 ft. for all bridge components and culvert slabs except as directed otherwise until the concrete has attained a compressive strength of 2,500 psi. Remove forms for other structural components as necessary.

Remove inside forms (walls and top slabs) for box culverts and sewers after concrete has attained a compressive strength of 1,800 psi if an approved overhead support system is used to transfer the weight of the top slab to the walls of the box culvert or sewer before removal of the support provided by the forms.

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Forms or parts of forms may be removed only if 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 to a depth of at least 1/2 in. from the concrete surface. Make the appliances so that metal may be removed without undue chipping or spalling of the concrete, and so that it leaves a smooth opening in the concrete surface when removed. Do not burn off rods, bolts, or ties.

Remove all forms and falsework unless otherwise directed.

- L. Defective Work.** Repair defective work as soon as possible. Remove and replace at the expense of the Contractor any defect that cannot be repaired to the satisfaction of the Engineer.
- M. Ordinary Surface Finish.** Apply an ordinary surface finish to all concrete surfaces as follows:
- Chip away all loose or broken material to sound concrete where porous, spalled, or honeycombed areas are visible after form removal.
 - Repair spalls by saw-cutting and chipping at least 1/2 in. deep, perpendicular to the surface to eliminate feather edges. Repair shallow cavities using a latex adhesive grout, cement mortar, or epoxy mortar as approved. Repair large areas using concrete as directed or approved.
 - Clean and fill holes or spalls caused by the removal of form ties, etc., with latex grout, cement grout, or epoxy grout as approved. Fill only the holes. Do not blend the patch with the surrounding concrete. On surfaces to receive a rub finish in accordance with Item 427, "Surface Finishes for Concrete," chip out exposed parts of metal chairs to a depth of 1/2 in. and repair the surface.
 - Remove all fins, runs, drips, or mortar from surfaces that will be exposed. Smooth all form marks and chamfer edges by grinding or dry-rubbing.
 - Ensure that all repairs are dense, well bonded, and properly cured. Finish exposed large repairs to blend with the surrounding concrete where a higher class of finish is not specified.

Unless noted otherwise, apply an ordinary surface finish as the final finish to the following exposed surfaces:

- inside and top of inlets,
- inside and top of manholes,
- inside of sewer appurtenances,
- inside of culvert barrels,

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- bottom of bridge slabs between girders or beams, and
- vertical and bottom surfaces of interior concrete beams or girders.

Form marks and chamfer edges do not need to be smoothed for the inside of culvert barrels and the bottom of bridge slabs between girders or beams.

420.5. Measurement. This Item will be measured by the cubic yard, square yard, foot, square foot, or by each structure.

- A. General.** Concrete quantities will be based on the dimensions shown on the plans or those established in writing by the Engineer.

In determining quantities, no deductions will be made for chamfers less than 2 in. or for embedded portions of steel or prestressed concrete beams, piling, anchor bolts, reinforcing steel, drains, weep holes, junction boxes, electrical or telephone conduit, ducts and voids for prestressed tendons, or embedded portions of light fixtures.

For slab and girder spans using pan forms, a quantity will be included for the screed setting required to provide proper camber in the roadway surface after form removal.

For slabs on steel or prestressed concrete beams, an estimated quantity for the haunch between the slab and beams will be included. No measurement will be made during construction for variation in the amount of haunch concrete due to variations in camber of the beams.

For cast-in-place slabs on slab beams, double-T beams, or box beams, the combination of span length, theoretical camber in beams, computed deflections, and plan vertical curve will be taken into account in determining the quantity for the slab.

Additional concrete that may be required by an adjustment of the profile grade line during construction, to insure proper slab thickness, will not be measured for payment.

Variation in concrete headwall quantity incurred when an alternate bid for pipe is permitted will not be cause for payment adjustment.

Mass placements may be either a plans quantity item or measured in place as indicated.

Quantities revised by a change in design, measured as specified, will be increased or decreased and included for payment.

- B. Plans Quantity.** Structure elements designated in Table 2 and measured by the cubic yard are plans quantity measurement items. The quantity to be paid for plans quantity items is the quantity shown in the

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proposal unless modified by Article 9.2, “Plans Quantity Measurement.” Additional measurements or calculations will be made if adjustments of quantities are required.

No adjustment will be made for footings or other in-ground elements where the Contractor has been allowed to place concrete in an excavation without forms.

**Table 2
Plans Quantity Payment
(Cubic Yard Measurement Only)**

Culverts and culvert wing walls	Abutments
Headwalls for pipe	Slab and girder spans (pan form)
Retaining walls	Footings
Inlets and manholes	Pile bent caps
Shear key concrete for box and slab beams	Concrete wearing surface on pre-cast box beams, slab beams or double-T beams
Bridge approach slabs	Cast-in-place concrete slab spans

Note: Other structure elements, including pier and bent concrete, may be paid for as “plans quantity” when shown on the plans.

C. Measured in Place. Items not paid for as “plans quantity” will be measured in place.

420.6. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for the various structure elements specified of the various classes of concrete. Mass placements, as defined in Section 420.4.G.14, “Mass Placements,” will be paid for separately for the various classes of concrete. This price is full compensation for furnishing, hauling, and mixing concrete materials; furnishing, bending, fabricating, splicing, welding and placing the required reinforcement; clips, blocks, metal spacers, ties, wire, or other materials used for fastening reinforcement in place; placing, finishing, curing, and grooving concrete; applying ordinary surface finish; furnishing and placing drains, metal flashing strips, and expansion-joint material; excavation, subgrade preparation, and disposal of excavated material for bridge approach slabs; and forms and falsework, equipment, labor, tools, and incidentals.

Diaphragm concrete will not be paid for directly but is subsidiary to the slab unless otherwise shown on the plans.

Design and installation of foundations for falsework is at the Contractor's expense.

The following procedure will be used to evaluate concrete where 1 or more project acceptance test specimens fail to meet the required design strength specified in Item 421, "Hydraulic Cement Concrete," or in the plans:

- The concrete for a given placement will be considered structurally adequate and accepted at full price if the average of all test results for specimens made at the time of placement meets the required design strength provided that no single test result is less than 85% of the required design strength.
- The Engineer will perform a structural review of the concrete to determine its adequacy to remain in service if the average of all test results for specimens made at the time of placement is less than the required design strength or if any test results are less than 85% of the required design strength. If cores are required to determine the strength of the in-situ concrete, take cores at locations designated by the Engineer in accordance with Tex-424-A. The coring and testing of the cores will be at the Contractor's expense. The Engineer will test the cores.
- If all of the tested cores meet the required design strength, the concrete will be paid for at the full price.
- If any of the tested cores do not meet the required design strength but the average strength attained is determined to be structurally adequate, the Engineer will determine the limits of the pay adjustment. The average strength of the cores tested will be used in the pay adjustment formula.
- Remove concrete that is not structurally adequate.
- Concrete that has been determined to be structurally adequate may be accepted at an adjusted price based on the following formula:

$$A = 0.10Bp + 0.75(Sa/Ss)^2 Bp$$

where:

A = Amount to be paid per unit of measure for the entire placement in question

Sa = Actual strength from cylinders or cores. Use values from cores, if taken.

Ss = Minimum required strength (specified)

Bp = Unit bid price.

- The decision to reject structurally inadequate concrete or to apply the pay adjustment will be made no later than 56 days after placement.

421.1 to 421.2

ITEM 421
HYDRAULIC CEMENT CONCRETE

421.1. Description. Furnish hydraulic cement concrete for concrete pavements, concrete structures, and other concrete construction.

421.2. Materials.

- A. Cement.** Furnish cement conforming to DMS-4600, "Hydraulic Cement."
- B. Supplementary Cementing Materials (SCM).**
 - 1. Fly Ash.** Furnish fly ash conforming to DMS-4610, "Fly Ash."
 - 2. Ultra-Fine Fly Ash (UFFA).** Furnish UFFA conforming to DMS-4610, "Fly Ash."
 - 3. Ground Granulated Blast-Furnace Slag (GGBFS).** Furnish GGBFS conforming to DMS-4620, "Ground Granulated Blast-Furnace Slag," Grade 100 or 120.
 - 4. Silica Fume.** Furnish silica fume conforming to DMS-4630, "Silica Fume."
 - 5. Metakaolin.** Furnish metakaolin conforming to DMS-4635, "Metakaolin."
- C. Chemical Admixtures.** Furnish admixtures conforming to DMS-4640, "Chemical Admixtures for Concrete." Do not use calcium chloride.
- D. Water.** Furnish mixing and curing water that is free from oils, acids, organic matter, or other deleterious substances. Water from municipal supplies approved by the Texas Department of Health will not require testing. When using water from other sources, provide test reports showing compliance with Table 1 before use.

Water that is a blend of concrete wash water and other acceptable water sources, certified by the concrete producer as complying with the requirements of both Table 1 and Table 2, may be used as mix water. Test the blended water weekly for 4 weeks for compliance with Table 1 and Table 2 or provide previous test results. Then test every month for compliance. Provide water test results upon request.

Table 1
Chemical Limits for Mix Water

Contaminant	Test Method	Maximum Concentration (ppm)
Chloride (Cl)	ASTM D 512	
Prestressed concrete		500
Bridge decks & superstructure		500
All other concrete		1,000
Sulfate (SO ₄)	ASTM D 516	1,000
Alkalies (Na ₂ O + 0.658K ₂ O)	ASTM D 4191 & ASTM D 4192	600
Total solids	AASHTO T 26	50,000

Table 2
Acceptance Criteria for Questionable Water Supplies

Property	Test Method	Limits
Compressive strength, min % control at 7 days	ASTM C 109 ¹	90
Time of set, deviation from control, Min.	ASTM C 191 ¹	from 60 early to 90 later

1. Base comparisons on fixed proportions and the same volume of test water compared to the control mix using city water or distilled water.

Do not use mix water that has an adverse effect on the air-entraining agent, on any other chemical admixture, or on strength or time of set of the concrete. When using white hydraulic cement, use mixing and curing water free of iron and other impurities that may cause staining or discoloration.

- E. Aggregate.** Supply aggregates that meet the definitions in Tex-100-E. Provide coarse and fine aggregates from sources listed in the Department's Concrete Rated Source Quality Catalog (CRSQC). Provide aggregate from non-listed sources only when tested and approved by the Engineer before use. Allow 30 calendar days for the Engineer to sample, test, and report results for non-listed sources. Do not combine approved material with unapproved material.
- 1. Coarse Aggregate.** Provide coarse aggregate consisting of durable particles of gravel, crushed blast furnace slag, recycled crushed hydraulic cement concrete, crushed stone, or combinations thereof that are free from frozen material and from injurious amounts of salt, alkali, vegetable matter, or other objectionable material, either

421.2 to 421.2

free or as an adherent coating. Provide coarse aggregate of uniform quality throughout.

Provide coarse aggregate that, when tested in accordance with Tex-413-A, has:

- at most 0.25% by weight of clay lumps,
- at most 1.0% by weight of shale, and
- at most 5.0% by weight of laminated and friable particles.

Wear must not be more than 40% when tested in accordance with Tex-410-A.

Unless otherwise shown on the plans, provide coarse aggregate with a 5-cycle magnesium sulfate soundness of not more than 18% when tested in accordance with Tex-411-A. Crushed recycled hydraulic cement concrete is not subject to the 5-cycle soundness test.

The loss by decantation as tested in accordance with Tex-406-A, plus the allowable weight of clay lumps, must not exceed 1.0% or the value shown on the plans, whichever is smaller. In the case of aggregates made primarily from crushing stone, if the material finer than the No. 200 sieve is established to be the dust of fracture and essentially free from clay or shale as established by Tex-406-A, Part III, the limit may be increased to 1.5%. When crushed limestone coarse aggregate is used in concrete pavements, the decant may exceed 1.0% but not more than 3.0% if the material finer than the No. 200 sieve is determined to be at least 67% calcium carbonate in accordance with Tex-406-A, Part III.

Unless otherwise specified, provide aggregate conforming to the gradation requirements shown in Table 3 when tested in accordance with Tex-401-A.

Table 3
Coarse Aggregate Gradation Chart

Aggregate Grade No. ¹	Nominal Size	Percent Passing on Each Sieve								
		2-1/2"	2"	1-1/2"	1"	3/4"	1/2"	3/8"	No. 4	No. 8
1	2"	100	80-100	50-85		20-40			0-5	
2 (467)	1-1/2"		100	95-100		35-70		10-30	0-5	
3	1-1/2"		100	95-100		60-90	25-60		0-5	
4 (57)	1"			100	95-100		25-60		0-10	0-5
5 (67)	3/4"				100	90-100		20-55	0-10	0-5
6 (7)	1/2"					100	90-100	40-70	0-15	0-5
7	3/8"						100	70-95	0-25	
8	3/8"						100	95-100	20-65	0-10

1. Corresponding ASTM C 33 gradation shown in parentheses.

- 2. Fine Aggregate.** Provide fine aggregate consisting of clean, hard, durable particles of natural or manufactured sand or a combination thereof with or without mineral filler. Provide fine aggregate free from frozen material and from injurious amounts of salt, alkali, vegetable matter, or other objectionable material, and containing no more than 0.5% clay lumps by weight in accordance with Tex-413-A.

Provide fine aggregate that does not show a color darker than standard when subjected to the color test for organic impurities in accordance with Tex-408-A.

Unless otherwise shown on the plans, use fine aggregate with an acid insoluble residue of at least 60% by weight when tested in accordance with Tex-612-J in all concrete subject to direct traffic.

Unless otherwise shown on the plans, when necessary, blend the fine aggregate to meet the acid insoluble residue requirement.

When blending, use the following equation:

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

where:

A1 = acid insoluble (%) of aggregate 1

A2 = acid insoluble (%) of aggregate 2

P1 = percent by weight of *A1* of the fine aggregate blend

P2 = percent by weight of *A2* of the fine aggregate blend.

Provide fine aggregate or combinations of aggregates, including mineral filler, conforming to the gradation requirements shown in

421.3 to 421.3

Table 4 when tested in accordance with Tex-401-A unless otherwise specified.

Table 4
Fine Aggregate Gradation Chart (Grade 1)

Sieve Size	Percent Passing
3/8 in.	100
No. 4	95–100
No. 8	80–100
No. 16	50–85
No. 30	25–65
No. 50	10–35 ¹
No. 100	0–10
No. 200	0–3 ²

1. 6–35 when sand equivalent value is greater than 85.

2. 0–6 for manufactured sand.

Unless otherwise shown on the plans, provide fine aggregate with a sand equivalent of at least 80 in accordance with Tex-203-F.

For all classes of concrete except Class K, provide fine aggregate with a fineness modulus between 2.30 and 3.10 as determined by Tex-402-A. For Class K concrete, provide a fine aggregate with a fineness modulus between 2.60 to 2.80 unless otherwise shown on the plans.

3. **Mineral Filler.** Provide mineral filler consisting of stone dust, clean crushed sand, or other approved inert material with 100% passing the No. 30 sieve and 65 to 100% passing the No. 200 sieve when tested in accordance with Tex-401-A.
- F. **Mortar and Grout.** When required or shown on the plans, provide mortar and grout consisting of 1 part hydraulic cement, 2 parts sand, and sufficient water to provide the desired consistency. Provide mortar with a consistency such that the mortar can be easily handled and spread by trowel. Provide grout of a consistency that will flow into and completely fill all voids.

421.3. Equipment.

- A. **Concrete Plants and Mixing Equipment.** Except for volumetric mixers (auger/mixer), each plant and truck mixer must be currently certified by the National Ready Mixed Concrete Association (NRMCA) or have an inspection report signed and sealed by a licensed professional engineer showing that concrete measuring, mixing, and

delivery equipment meets all requirements of ASTM C 94. A new certification or signed and sealed report is required every time a plant is moved. Plants with a licensed engineer's inspection require reinspection every 2 years. Provide a copy of the certification or the signed and sealed inspection report to the Engineer. When equipment or facilities fail to meet specification requirements, remove them from service until corrected.

1. **Scales.** Check all scales prior to beginning of operations, after each move, or whenever their accuracy or adequacy is questioned, and at least once every 6 mo. Immediately correct deficiencies, and recalibrate. Provide a record of calibration showing scales in compliance with ASTM C 94 requirements. Check batching accuracy of volumetric water batching devices and admixture dispensing devices at least every 90 days. Perform daily checks as necessary to ensure measuring accuracy.
2. **Volumetric Mixers.** Provide volumetric mixers with rating plates defining the capacity and the performance of the mixer in accordance with the Volumetric Mixer Manufacturers Bureau or equivalent. Provide volumetric mixers that comply with ASTM C 685. Provide test data showing mixers meet the uniformity test requirements of Tex-472-A.
3. **Agitators and Truck and Stationary Mixers.** Inspect and furnish inspection reports on truck mixers and agitators annually. If an inspection within 12 mo. is not practical, a 2-mo. grace period (for a maximum of 14 mo. between inspections) is permitted. Include in the report the condition of blades and fins and their percent wear from the original manufacturer's design. Repair mixing equipment exhibiting 10% or more wear before use. Provide truck mixers and agitators equipped with means to readily verify the number of revolutions of the drum, blades, or paddles.

Provide stationary and truck mixers capable of combining the ingredients of the concrete within the specified time or the number of revolutions specified into a thoroughly mixed and uniform mass and capable of discharging the concrete so that at least 5 of the 6 requirements of Tex-472-A are met.

As directed, to resolve issues of mix uniformity and mixer performance, perform concrete uniformity tests on mixers or agitators in accordance with Tex-472-A.

Perform the mixer or agitator uniformity test at the full rated capacity of the equipment and within the maximum mixing time or

421.4 to 421.4

maximum number of revolutions. Remove from service all equipment that fails the uniformity test.

Inspect and maintain mixers and agitators. Keep them reasonably free of concrete buildup, and repair or replace worn or damaged blades or fins.

Ensure all mixers have a plate affixed showing manufacturer's recommended operating speed and rated capacity for mixing and agitating.

- B. Hauling Equipment.** Provide hauling equipment capable of maintaining the mixed concrete in a thoroughly mixed and uniform mass and of discharging the concrete with a satisfactory degree of uniformity.

When using non-agitating equipment for transporting concrete, provide equipment with smooth, mortar-tight metal containers equipped with gates that prevent accidental discharge of the concrete.

- C. Testing Equipment.** Unless otherwise shown on the plans or specified, in accordance with the pertinent test procedure, furnish and maintain:
- test molds,
 - curing facilities,
 - maturity meters if used, and
 - wheelbarrow or other container acceptable for the sampling of the concrete.

Provide strength-testing equipment in accordance with the Contract controlling test unless shown otherwise.

421.4. Construction.

- A. Classification and Mix Design.** Furnish mix designs using ACI 211, "Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete," or other approved procedures for the classes of concrete required in accordance with Table 5. Do not exceed the maximum water-to-cementitious-material ratio.

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

To account for production variability and ensure minimum compressive strength requirements are met, over-design the mix in accordance with Table 6.

- 1. Cementitious Materials.** Use cementitious materials from prequalified sources; otherwise, request sampling and testing for approval before use. Unless otherwise specified or approved, limit cementitious material content to no more than 700 lb. per cubic yard. When supplementary cementing materials are used, “cement” is defined as “cement plus supplementary cementing material.”

Use Type III cement only in precast concrete or when specified or permitted.

For monolithic placements, use cement of the same type and from the same source.

When sulfate-resistant concrete is required, use mix design options 1, 2, 3, or 4 given in Section 421.4.A.6, “Mix Design Options,” using Type I/II, II, V, IP, or IS cement. Do not use Class C fly ash in sulfate-resistant concrete.

Do not use supplementary cementing materials when white hydraulic cement is specified.

Table 5
Concrete Classes

Class of Concrete	Design Strength, Min. 28-day f'_c (psi)	Maximum W/C Ratio ¹	Coarse Aggregate Grades ^{2,3}	General Usage ⁴
A	3,000	0.60	1-4, 8	Inlets, manholes, curb, gutter, curb & gutter, conc. retards, sidewalks, driveways, backup walls, anchors
B	2,000	0.60	2-7	Riprap, small roadside signs, and anchors
C ⁵	3,600	0.45	1-6	Drilled shafts, bridge substructure, bridge railing, culverts except top slab of direct traffic culverts, headwalls, wing walls, approach slabs, concrete traffic barrier (cast-in-place)
D	1,500	0.60	2-7	Riprap
E	3,000	0.50	2-5	Seal concrete
F ⁵	Note 6	0.45	2-5	Railroad structures; occasionally for bridge piers, columns, or bents
H ⁵	Note 6	0.45	3-6	Prestressed concrete beams, boxes, piling, and concrete traffic barrier (precast)
S ⁵	4,000	0.45	2-5	Bridge slabs, top slabs of direct traffic culverts
P	See Item 360	0.45	2-3	Concrete pavement
DC ⁵	5,500	0.40	6	Dense conc. overlay
CO ⁵	4,600	0.40	6	Conc. overlay
LMC ⁵	4,000	0.40	6-8	Latex-modified concrete overlay
SS ⁵	Note 7	0.45	4-6	Slurry displacement shafts, underwater drilled shafts
K ⁵	Note 6	0.45	Note 6	Note 6
HES	Note 6	0.45	Note 6	Note 6

1. Maximum water-cement or water-cementitious ratio by weight.
2. Unless otherwise permitted, do not use Grade 1 coarse aggregate except in massive foundations with 4-in. minimum clear spacing between reinforcing steel bars. Do not use Grade 1 aggregate in drilled shafts.
3. Unless otherwise approved, use Grade 8 aggregate in extruded curbs.
4. For information only.
5. Structural concrete classes.
6. As shown on the plans or specified.
7. Cementitious material content shall be minimum 658 lb/cy of concrete.

Table 6
Over Design to Meet Compressive Strength Requirements¹

No. of Tests ^{2,3}	Standard Deviation, psi				
	300	400	500	600	700
15	470	620	850	1,120	1,390
20	430	580	760	1,010	1,260
30 or more	400	530	670	900	1,130

1. When designing the mix, add the tabulated amounts to the minimum design strength in Table 5.

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 of the specified strength may be used.

3. If less than 15 prior tests are available, the overdesign should be 1,000 psi for specified strength less than 3,000 psi, 1,200 psi for specified strengths from 3,000 to 5,000 psi and 1,400 psi for specified strengths greater than 5,000 psi.

2. **Aggregates.** Limit the use of recycled crushed hydraulic cement concrete as a coarse or fine aggregate to Class A, B, D, E, and P concrete. Limit recycled crushed concrete fine aggregate to a maximum of 20% of the fine aggregate.

When white hydraulic cement is specified, use light-colored aggregates.

3. **Chemical Admixtures.** Use only preapproved concrete chemical admixtures from the list of prequalified concrete admixtures maintained by the Construction Division. Submit non-preapproved admixtures for testing to the Engineer for approval. Do not use high-range water-reducing admixtures (Type F or G) or accelerating admixtures (Type C or E) in bridge deck concrete.
4. **Air Entrainment.** Air-entrain all concrete except for Class B in accordance with Table 7 unless otherwise shown on the plans. Use moderate exposure values unless otherwise specified. 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 tests.

421.4 to 421.4

Table 7
Air Entrainment

Nominal Maximum Aggregate Size, in.	% Air ¹	
	Moderate Exposure	Severe Exposure
3/8 (Grades 7 & 8)	6	7-1/2
1/2 (Grade 6)	5-1/2	7
3/4 (Grade 5)	5	6
1 (Grade 4)	4-1/2	6
1-1/2 (Grades 2 & 3)	4-1/2	5-1/2
2 (Grade 1)	4	5

1. For specified concrete strengths above 5,000 psi a reduction of 1 percentage point is permitted.

- 5. Slump.** Unless otherwise specified, provide concrete slump in accordance with Table 8 using the lowest slump possible that can be placed and finished efficiently without segregation or honeycombing.

Concrete that exceeds the maximum acceptable placement slump at time of delivery will be rejected.

When approved, the slump of a given concrete mix may be increased above the values shown in Table 8 using chemical admixtures, provided that the admixture-treated concrete has the same or lower water-cement or water-cementitious-material ratio and does not exhibit segregation or excessive bleeding. Request approval for the mix design sufficiently in advance for proper evaluation by the Engineer.

424.4 to 425.2

1. **Prestressed Members.** Store and handle prestressed members in accordance with Item 425, "Precast Prestressed Concrete Structural Members."
2. **Nonstressed Members.** Store and handle nonstressed members in a manner to avoid excessive bending stresses and damage.

The storage area must be clean and well drained. Prevent excessive or differential settlement of members by storing them on stable ground and on dunnage of sufficient size, shape, and strength, to prevent crushing.

When members are stacked, separate them with blocking, arranged in vertical planes, that does not crush under load. Stack members so that lifting devices are accessible and undamaged.

Rearrange improperly stored members and inspect them for damage. Members that are improperly stored and become cracked, warped, or otherwise damaged in storage may be cause for rejection.

Dunnage and blocking material must not cause damage or stains that are unacceptable for the required finish.

424.4. Measurement and Payment. The work performed, materials furnished, equipment, labor, tools, and incidentals will not be measured or paid for directly but will be subsidiary to bid items of the Contract.

ITEM 425

PRECAST PRESTRESSED CONCRETE STRUCTURAL MEMBERS

425.1. Description. Furnish and erect precast prestressed concrete members fabricated by pretensioning, post-tensioning, or a combination of the two.

425.2. Materials. Use materials that meet requirements of the following Items:

- Item 421, "Hydraulic Cement Concrete"
- Item 426, "Prestressing"
- Item 434, "Elastomeric Bridge Bearings"
- Item 440, "Reinforcing Steel"
- Item 442, "Metal For Structures"

425.3 to 425.3

- DMS-4650, “Hydraulic Cement Concrete Curing Materials and Evaporation Retardants”
- DMS-6100, “Epoxies and Adhesives.”

The bedding strip for precast prestressed concrete bridge deck panels must be extruded polystyrene conforming to ASTM C 578, Type VI, with:

- maximum water absorption of 0.1% by volume tested in accordance with ASTM C 272 and
- minimum compressive strength of 40 psi tested in accordance with ASTM D 1621 by loading the bedding strip sample perpendicular to the skin (bearing) face.

Provide a manufacturer’s certification stating that the bedding strip meets the requirements of this Item. Use adhesive or bonding agents for polystyrene as recommended by the polystyrene manufacturer.

Use other materials as panel bedding strips only after submitting suitable data for structural review and approval.

The dimensions for panel bedding strips must conform to those shown on the plans.

425.3. Construction. Fabricate precast prestressed concrete members in accordance with Item 424, “Precast Concrete Structures (Fabrication).”

A. Handling, Storing, Hauling, and Erection. Properly handle, store, haul, and erect all members so that they are placed in the structure without damage.

Unless approved on shop or erection drawings, maintain members in an upright position at all times, and raise and support them near the ends to prevent torsion. Lift members with approved lifting devices as shown on the shop drawings or as approved.

Do not move members from the casting yard until all requirements of the pertinent items have been met. Do not haul beams to the project site until at least 7 days have elapsed since casting unless otherwise approved.

The storage area must be clean and well drained. Prevent excessive or differential settlement of members by storing them on:

- stable ground and
- dunnage of sufficient size, shape, and strength to prevent crushing.

Place dunnage a distance not greater than 3% of the beam length from the beam ends. When approved, cantilever beams may be supported at locations other than near the ends. Support concrete box beams and

425.4 to 425.5

U-beams under the solid end block area during handling, storage, hauling, and erection.

When members are stacked, separate them with blocking arranged in vertical planes that will not crush under load. Stack members so that lifting devices are not damaged.

Rearrange improperly stored members and inspect them for damage. Members that are improperly stored and become cracked, warped, or otherwise damaged in storage may be rejected.

Securely tie or brace all beams during erection in accordance with minimum erection and bracing standards. When railroad or roadway traffic must be maintained beneath beams already placed, protect traffic against falling objects during the erection of diaphragms and other structural members, during the placing of cast-in-place concrete, and during the erection and dismantling of forms. Protect traffic with nets or flooring with openings not larger than 1 in., or as approved.

When erecting precast prestressed concrete bridge deck panels, fit mating surfaces to prevent excessive grout leakage. If such fit is not provided, fill the joint with grout or seal it with an acceptable caulking compound before placing the cast-in-place portion of the slab.

After slab placement, finish surfaces of beams or other members in accordance with Section 420.4.M, "Ordinary Surface Finish," and Item 427, "Surface Finishes for Concrete."

Correct beam discrepancies including but not limited to horizontal misalignment or variations in vertical camber, to achieve a satisfactory completed structure, at no additional expense to the Department. Correction may require replacement of the member.

425.4. Measurement. This Item will be measured by the foot, square foot, square yard, cubic yard, or each member.

This is a plans quantity measurement Item. The quantity to be paid is the quantity shown in the proposal, unless modified by Article 9.2, "Plans Quantity Measurement." Additional measurement or calculations will be made if adjustments of quantities are required.

425.5. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Prestressed Concrete" of the specified structural component and type or size. This price is full compensation for fabricating, hauling, and erection of the members; furnishing and tensioning of prestressing steel; furnishing and placing

reinforcing steel and duct; furnishing and placing bearing plates, elastomeric bearings, bars, anchorage plates, and appurtenances; grouting holes; repairs; special treatment of end anchorages and shoes as required; erection bracing; and equipment, labor, tools, and incidentals.

Precast prestressed concrete bridge deck panels will not be paid for directly but will be subsidiary to pertinent Items.

Precast prestressed concrete piling will be paid for as specified in Item 409, "Prestressed Concrete Piling."

ITEM 426 PRESTRESSING

426.1. Description. Furnish, store, and handle prestressing materials and perform prestressing of precast members and cast-in-place structural units. For this Item, the following definitions apply:

- **Prestressing.** The introduction of internal stresses (pretensioning or post-tensioning) into a structural member by tensioning and anchoring strands, bars, or wires to counteract the stresses resulting from the applied load.
- **Pretensioning.** The application of prestressing force to the tensioning devices before casting concrete.
- **Post-Tensioning.** The application of prestressing force to the tensioning devices after concrete has hardened.
- **Tendon.** Any single unit used to apply prestressing force to the member. For post-tensioned units, a tendon is a bar, group of wires, or group of strands having common end anchorage.
- **Post-Tensioning System.** A complete tendon with couplers, end anchorage, and all other necessary hardware.

426.2. Materials. Furnish materials that meet requirements of the following Items:

- Item 420, "Concrete Structures"
 - Item 421, "Hydraulic Cement Concrete"
 - Item 434, "Elastomeric Bridge Bearings"
 - Item 440, "Reinforcing Steel"
 - Item 442, "Metal For Structures"
 - DMS-4670, "Grouts for Post-Tensioning"
 - DMS-6310, "Joint Sealants and Fillers."
- A. Prestressing Hardware.** Furnish prestressing hardware that meets the manufacturer's specifications.

428.1 to 428.3

When a surface finish for concrete is specified as a pay item, the work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Adhesive Grout Finish," "Concrete Paint Finish," "Opaque Sealer Finish," "742 Appearance Coating Finish," "Epoxy Paint Finish," "Blast Finish," or "Rub Finish." This price is full compensation for materials; cleaning and preparing surfaces; application of materials; and equipment, labor, tools, and incidentals.

Off-the-form, form liner, or exposed aggregate finishes (including anti-graffiti coating) will not be paid for under this Item but are subsidiary to other pertinent Items.

ITEM 428

CONCRETE SURFACE TREATMENT

428.1. Description. Prepare surface and apply a linseed oil treatment or a penetrating-type sealant treatment to concrete surfaces.

428.2. Materials. Furnish materials required by the class of surface treatment shown on the plans.

A. Surface Treatment Class I. Provide mixture containing a minimum of 50% and a maximum of 70% boiled linseed oil by volume. Use mineral spirits as the complement component for any ambient temperature range above 40°F, or kerosene for ambient temperature range above 70°F. Provide material in accordance with the following specifications:

- Boiled linseed oil: ASTM D 260
- Mineral spirits: ASTM D 235
- Kerosene: ASTM D 3699.

Provide combined mixture in clean, leakproof, labeled containers. Clearly state the contents on all the containers.

B. Surface Treatment Class II. Provide penetrating surface treatment in accordance with DMS-8140, "Concrete Surface Treatment (Penetrating)."

428.3. Construction Methods. Treat the upper surfaces of the roadway slab (including direct traffic culverts), bridge sidewalks and medians, the inside faces of curbs and concrete rails, and all other areas shown in the plans. Do not treat surfaces given a higher finish as defined in Item 427, "Surface Finishes for Concrete," unless otherwise shown on the plans.

428.3 to 428.3

- A. Surface Treatment Class I.** Clean concrete surfaces to remove contaminants that retard or prevent absorption of the mixture before treatment application. Do not apply the treatment before required concrete curing is complete, while the surface is damp, or when the ambient temperature is below 40°F. Do not heat the mixture. Use a spray applicator equipped with a spray bar to apply the treatment material unless directed otherwise.

Apply the material in 2 stages. Apply at an approximate rate of 40 sq. yd. per gallon for the first stage and 67 sq. yd. per gallon for the second stage for a total coverage of 25 sq. yd. per gallon. Wait a minimum of 4 hr. after the first application before applying the second application. Apply so that a uniform coverage is obtained.

Remove any excess mixture remaining on the surface 4 hr. after the second application or cover with an application of fine sand. Do not allow traffic on the treated surface for 24 hr. after the final application.

- B. Surface Treatment Class II.** Refer to the manufacturer's specifications for instruction on the use of the treatment material in addition to the requirements of this Item.

Clean the concrete surfaces to remove all visible curing compound and any other contaminants that retard or prevent penetration of the mixture before treatment application. Demonstrate the method of cleaning to the Engineer by preparing a 100-sq. ft. area before proceeding with complete cleaning. Do not damage the concrete surface to the point that the coarse aggregate is exposed. Acceptance of the entire cleaned surface by the Engineer is required before the application of the treatment material.

Apply the treatment material no sooner than 14 days after casting the concrete and a minimum of 1 day after curing blankets have been removed.

Apply treatment material to a dry surface no sooner than 24 hours after any water has reached the concrete surface. Apply treatment material when surface temperature is between 40°F and 100°F.

Do not dilute or alter the treatment material.

Apply the treatment material at a rate of 125 sq. ft. of surface area per gallon. Treat the upper side of horizontal and near-horizontal surfaces in 1 pass or coat. Treat the vertical and overhead surfaces in 2 passes or coats. Apply the first coat at a rate of 165 sq. ft. of surface area per gallon, and apply the second coat at a rate of 500 sq. ft. of surface area

428.4 to 429.2

per gallon. Apply the second coat within 1 hr. of application of the first coat.

Use a spray applicator equipped with a spray bar to apply the treatment material to deck surfaces.

Apply the treatment material at a uniform rate, covering the entire surface being treated.

Follow the treatment material manufacturer's specifications regarding the post-wetting of the treated surface and required lapse time before traffic is permitted on the treated surface.

428.4. Measurement. This Item will be measured by the square yard of concrete surface treated. This is a plans quantity measurement Item. The quantity to be paid is the quantity shown in the proposal, unless modified by Article 9.2, "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.

428.5. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price for "Concrete Surface Treatment (Class I)" or "Concrete Surface Treatment (Class II)." This price is full compensation for furnishing materials and for equipment, labor, tools, and incidentals.

ITEM 429

CONCRETE STRUCTURE REPAIR

429.1. Description. Remove unsound concrete, repair spalled or delaminated concrete, and replace concrete with repair materials.

429.2. Materials. Provide materials in accordance with the requirements of the following Items:

- Item 420, "Concrete Structures"
- Item 421, "Hydraulic Cement Concrete"
- Item 431, "Pneumatically Placed Concrete"
- Item 440, "Reinforcing Steel"
- DMS-6100, "Epoxy and Adhesives"
- DMS-4655, "Rapid-Hardening Cementing Materials for Concrete Repair."

For all repairs, provide repair materials suitable for the appropriate horizontal, vertical, or overhead application. Obtain approval for any

450.1 to 450.3

ITEM 450 RAILING

450.1. Description. Construct railing of concrete, steel, aluminum, or a combination of these materials, including necessary anchorage for the railing on bridges, culverts, walls, or other structures as shown on the plans.

450.2. Materials. Use materials that conform to requirements of the following Items:

- Item 421, “Hydraulic Cement Concrete”
- Item 440, “Reinforcing Steel”
- Item 442, “Metal for Structures”
- Item 445, “Galvanizing”
- Item 446, “Cleaning and Painting Steel”
- Item 540, “Metal Beam Guard Fence.”

450.3. Construction. Construct railing in accordance with details, alignment, and grade designated on the plans. Unless otherwise directed, do not place railing until falsework or formwork, if any, for the span has been released. During construction, ensure that expansion joints in the railing will function properly after the railing is installed.

If the plans allow either steel or aluminum options for a particular railing type, furnish either steel or aluminum but not both for the entire Contract.

A. Metal Railing.

1. **General.** Furnish metal beam rail elements in accordance with Item 540, “Metal Beam Guard Fence.”

Fabricate and erect metal railing according to the pertinent provisions of Item 441, “Steel Structures,” and the requirements of this Item.

When required by the plans, prepare and submit for approval the required shop or erection drawings in accordance with Item 441. Show all splice locations and details on the shop or erection drawings. Splice members only as provided on the plans.

Field weld when required in accordance with Item 448, “Structural Field Welding.”

2. **Fabrication.** Fabricate metal railing and post panels in sections conforming to the details shown in the plans and field-verified lines and grades. Fabricate adjacent sections so that they will accurately engage each other in the field. Match mark each pair of

sections so they can be erected in the same position in which they were fabricated.

Fabricate metal rail elements included as part of the railing system to the dimensions and cross-sections shown on the plans and within a tolerance of 1/4 in. per 10 ft. in the straightness of either edge. Joint and connect metal rail elements to the rail posts as shown on the plans, lapping metal rail elements in the direction of traffic in the adjacent lane. Unless otherwise shown on the plans, bolts and nuts for metal railing should meet requirements of ASTM A 307 and be galvanized in accordance with Item 445, "Galvanizing."

Fabricate aluminum in accordance with AWS D1.2, *Structural Welding Code—Aluminum*.

To facilitate bending or straightening, aluminum materials other than castings may be heated to a temperature up to 400°F for no more than 30 min.

3. **Castings.** Provide permanent mold castings of the materials specified that are true to pattern in form and dimensions and of uniform quality and condition. Castings must be free from cracks and defects such as blowholes, porosity, hard-spots, or shrinkage that could affect their suitability for use. Repair minor defects in aluminum castings by an approved inert gas-welding process. Ensure that finished castings are free of burrs, fins, discoloration, and mold marks and that they have a uniform appearance and texture.

Produce castings under radiographic control sufficient to establish and verify a product free from harmful internal defects. When heat-treating is required, heat-treat the entire lot of castings to the specified temper.

Permanently mark the heat or lot number on the web or top of the base of all castings. Furnish mill test reports showing the heat or lot number, chemical composition, tensile strength, elongation, and number of pieces for each casting heat or lot. For aluminum castings, a heat or lot should consist of not more than 1,000 lb. of trimmed castings when produced from batch type furnaces, or 2,000 lb. when produced from a continuous furnace during a period of no more than 8 consecutive hours. Furnish the entire number of acceptable posts cast from each heat or lot except when a portion is required to complete a project.

450.4 to 450.5

4. **Corrosion Protection.** Provide protective coating for all metal railing unless otherwise noted on the plans. Galvanize all portions of steel railing after fabrication in accordance with Item 445, "Galvanizing," unless otherwise noted on the plans. When painting is specified on the plans, provide the paint system shown on the plans. Apply paint in accordance with Item 446, "Cleaning and Painting Steel." Repair any damaged galvanizing after erection in accordance with Item 445.

Aluminum railing and galvanized steel railing do not require field painting. Before final acceptance, clean extrusion marks, grease, and dirt from the railing.

5. **Storage.** Store railing materials above the ground on platforms, skids, or other supports, and keep them free from grease, dirt, and contact with dissimilar metals. Avoid scratching, marring, denting, discoloring, or otherwise damaging the railing.

- B. **Concrete Railing.** Provide concrete portions of railing in accordance with the requirements of Item 420, "Concrete Structures," and requirements of this Item. Construct forms so that the railing line and grade can be checked after the concrete has been placed but before initial set. Do not disturb the form alignment during finish floating of the railing tops. Exercise particular care in other construction to avoid disturbing or vibrating the span with the newly placed railing.

Provide precast members conforming to Item 424, "Precast Concrete Structures (Fabrication)."

Concrete railing may be constructed using approved slip-form equipment. Provide sensor control for both line and grade.

- C. **Tests.** The Engineer will sample cast aluminum posts for testing in accordance with Tex-731-I to verify the material requirements of Item 442, "Metal for Structures." Metal beam rail elements may be sampled in accordance with Tex-713-I. The Engineer may sample bolts and nuts in accordance with Tex-708-I for galvanized coating testing.

450.4. Measurement. This Item will be measured by the foot.

This is a plans quantity measurement Item. The quantity to be paid for is the quantity shown in the proposal except as modified by Article 9.2, "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.

450.5. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement"

450.5 to 452.4

will be paid for at the unit price bid for "Railing" of the type specified. This price will be full compensation for furnishing, preparing, and placing concrete, expansion joint material, reinforcing steel, structural steel, aluminum, cast steel, pipe, anchor bolts, tie-in anchorage to approach railing or guard fence, anchorage devices for attaching metal beam guard fence or end treatments, and all other materials required in the finished railing; removal and disposal of salvageable materials; and hardware, paint and painting of metal railing, galvanizing, equipment, labor, tools, and incidentals.

ITEM 452 REMOVING RAILING

452.1. Description. Remove railing on 1 or both sides of the structure as directed. Dispose of or stockpile removed railing that is not to be reused on the structure.

452.2. Equipment. Use air-driven equipment or other suitable means to remove railing. Do not use explosives.

452.3. Construction. Remove existing railing to the lines and grades shown on the plans. Do not damage any portion of the structure that is to remain in place. Replace any concrete removed beyond the neat lines or other established lines at the Contractor's expense.

Incorporate reinforcing steel into the new concrete railing with a minimum 2 in. of clear cover. If existing reinforcing steel in concrete posts cannot be reused as dowels, cut it off at least 1 in. below the finished surface of the concrete. Repair as directed any concrete damaged from making the cut-off.

Refinish the top of the concrete slab where the railing is removed but not replaced to leave a neat surface as specified in the plans and in accordance with Item 420, "Concrete Structures."

Carefully dismantle all material deemed salvageable for reuse, and place it in neat piles along the right of way at approved loading points. Remove portions of railing not deemed salvable, and dispose of them in accordance with federal, state, and local regulations.

452.4. Measurement. This Item will be measured by the foot in its original position.

453.4 to 454.3

Upon removal of the railing, deliver salvageable materials furnished by the Department to the storage site designated on the plans.

As directed and in accordance with Item 429, "Concrete Structure Repair," repair any damage, including erection holes, caused to the bridge by the erection of temporary railing,

Repair, refurbish, or replace any temporary railing to be used as permanent railing on the new structure before installing it in its final position. All permanent railing must meet plan requirements.

453.4. Measurement. This Item will be measured by the lump sum.

453.5. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Temporary Railing." This price is full compensation for furnishing materials except those designated on the plans to be furnished by others; preparation, loading, hauling and erection; painting, maintaining, moving, and removing railing; stockpiling rail material on the right of way; and equipment, labor, tools, and incidentals.

ITEM 454

BRIDGE EXPANSION JOINTS

454.1. Description. Furnish and install bridge expansion joints.

454.2. Materials. Provide materials in accordance with the requirements of the following Items:

- Item 442, "Metal for Structures"
- DMS-6140, "Elastomeric Concrete for Bridge Joint Systems"
- DMS-6310, "Joint Sealants and Fillers," Class 7 (Low-Modulus Silicone, Rapid-Curing, Self-Leveling)
- ASTM D-5973, "Standard Specification for Elastomeric Strip Seals with Steel Locking Edge Rails Used in Expansion Joint Sealing."

If required, use primers recommended by the manufacturer of the sealant. Use backer rods compatible with the sealant that do not react or bond together.

454.3. Construction. Place expansion joints to conform to the finished grade of the roadway surface. Set the joint opening at the dimension shown on the plans for 70°F, adjusted for the temperature at the time of installation. For sealed joint openings, place the seal for the full length of

454.3 to 454.3

the joint and, when required, extend it into the parapet wall on the low side or sides of the bridge.

- A. **Sealed Expansion Joint (SEJ).** Choose an approved joint system that conforms to the joint type and the design requirements shown on the plans. Secure each side of the joint by welding it to the adjacent reinforcing steel or other attachments as approved. Remove any connection holding the joint halves together immediately after each joint half is secured in place. Install the neoprene seal as a continuous piece to form a watertight seal.
- B. **Armor Joint.** Place steel armor plates as shown on the plans. Secure each side of the joint by welding it to adjacent reinforcing steel or other attachments as approved. Remove any connection holding joint halves together immediately after each joint half is secured in place.

Seal the joint when specified. Abrasive blast clean the vertical faces of the steel plates where the sealant will be in contact to remove all visible rust, paint, mill scale, and other forms of contamination, leaving a white metal appearance. Clean the concrete in contact with the sealant by an approved method in accordance with the manufacturer's specifications before placing sealant. After cleaning, air-blast the joint to remove all dust. Place sealant in accordance with the manufacturer's specifications and as shown on the plans. Repair damage to paint protection system above the seal when shown on plans for steel armor plates to be painted.

- C. **Header-Type Expansion Joint.** Meet with the manufacturer's representative and the Engineer to discuss the required installation procedures of the materials before beginning the work. Perform the work in accordance with the manufacturer's printed instructions and as discussed in the meeting.
 - 1. **Header.** Create the required void in the concrete surface or asphalt overlay to accept the header material in accordance with the details shown on the plans. Extend the depth of the void in the asphalt overlay to sound concrete. Remove any unsound steel or concrete and repair concrete in accordance with Item 429, "Concrete Structure Repair." Use header material as repair material only when approved. Clean the voided region of all materials that could inhibit the bond between the header material and concrete or steel. Form the joint opening to the required width shown on the plans.

Do not place materials until approved. Place material on a clean, sound, and dry base when the ambient temperature is at least 45°F

454.4 to 454.5

and rising or as required by the manufacturer. Do not place material on wet substrate or when raining.

Cure for the duration required by the manufacturer prior to opening to traffic.

Tool or grind the upper corner of the header adjacent to the opening to a 1/4-in. radius.

2. **Sealant.** Clean the joint opening of forming material, existing seal, and other material that will inhibit the bond between the header material and the sealant. Abrasive blast clean surfaces in contact with the sealant. Place an approved backer rod and the sealant as shown on the plans. Place sealant when ambient temperature is rising and is between 55°F and 85°F to provide for adequate joint opening and compression of the sealant during curing.

454.4. Measurement. Sealed expansion joints and armor joints will be measured by the foot. Header-type expansion joints will be measured by the foot or by the cubic foot of header material and foot of sealant. Length measurement will be along the centerline of the joint at the surface of the roadway and up into the parapet. Calculate volume for header-type expansion joints using the length and width shown on the plans and the header depth measured in place.

Sealed expansion joints and armor joints are a plans quantity measurement Item. The quantity to be paid is the quantity shown in the proposal unless modified by Article 9.2, "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.

454.5. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Sealed Expansion Joint" of the size (minimum total movement capacity) and designation specified, "Armor Joint," "Armor Joint (With Seal)," and "Header-Type Expansion Joint." Sealing the joint will be subsidiary to these items with the exception of the header-type expansion joint when the header is paid for by volume measurement. This price is full compensation for furnishing and installing the joint systems including steel; and for materials, tools, equipment, labor, and incidentals.

If volume measurement for the header material is specified, the header material will be paid for at the unit price bid for "Header-Type Expansion Joint" and the sealant will be paid for at the unit price bid for "Joint

458.1 to 458.2

Sealant.” This price is full compensation for furnishing and installing the joint systems and for materials, tools, equipment, labor, and incidentals.

ITEM 458

WATERPROOFING MEMBRANES FOR STRUCTURES

458.1. Description. Furnish and place waterproofing membranes on concrete and steel bridge decks of railroad and other types of structures.

458.2. Materials.

A. Materials to be Furnished. Furnish waterproofing materials listed below in accordance with DMS-6300, “Waterproofing”:

- asphalt for mopping above ground,
- asphalt for mopping below ground
- asphaltic primer,
- treated cotton fabric,
- self-adhering polyethylene,
- coal-tar-modified urethane,
- rubberized asphalt with preformed board membrane,
- asphalt plank,
- asphalt mat,
- rubberized asphalt with plastic film,
- asphaltic panels,
- plastic cement, and
- cold asphalt base emulsion.

Furnish butyl rubber membrane and ethylene-propylene-diene terpolymer (EPDM) sheeting in accordance with ASTM D 6134.

Deliver materials requiring sampling and testing to the work site a minimum of 3 weeks before use. When authorized, materials for waterproofing may be tested and approved before delivery to the worksite.

B. Types. Provide the following types of waterproofing as shown on the plans or as directed.

1. **Type 1.** Butyl rubber membrane applied to a surface with a proper adhesive without protective planking and in accordance with the details shown on the plans. Provide a minimum thickness of 1/16 in. unless otherwise shown on the plans.
2. **Type 2.** A single asphaltic primer coat and 1 mopping of asphalt.

pedestals will be measured in accordance with Item 420, "Concrete Structures."

495.5. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid at the unit price bid for "Raising Existing Structure." This price is full compensation for shoring, falsework, jacking, fabric pads or elastomeric bearings, labor, tools, and equipment and for all materials except new pedestals. Pedestals will be paid for in accordance with Item 442, "Metal for Structures," or Item 420, "Concrete Structures."

ITEM 496 REMOVING STRUCTURES

496.1. Description. Remove and either dispose of or salvage structures.

496.2. Construction.

A. Removal.

1. **Pipes.** Avoid damaging appurtenances determined by the Engineer to be salvageable.
2. **Concrete, Brick, or Stone Structures.** Portions of structures that will not interfere with the proposed construction may remain in place 2 ft. or more below the permanent ground line. Square off remaining structures and cut reinforcement flush with the surface of the concrete.
3. **Steel Structures.** Dismantle steel to be retained by the Department or re-erected by cold-cutting fastener heads and punching or drilling the remaining portion of the fastener, air-arc gouging welded connections, and flame-cutting beams along a straight line. The Engineer may approve other methods of cutting. Cut beams at the locations shown in the plans. Match-mark steel to be re-erected with paint in accordance with the erection drawings. Remove steel piles or cut off 2 ft. or more below the permanent ground line.
4. **Timber Structures.** Remove all fasteners from timber determined by the engineer to be salvageable. Remove timber piles or cut off 2 ft. or more below the permanent ground line.

B. Salvage. Avoid damage to materials shown in the plans to be salvaged. Deliver materials to be retained by the Department to the location shown in the plans. Block up salvaged steel materials off the ground.

496.3 to 497.4

- C. Disposal.** Material removed that is not deemed to be salvageable is the property of the Contractor. Dispose of removed material off the right of way in accordance with federal, state, and local regulations.
- D. Backfill.** Backfill excavation and voids to the original ground line if resulting from the removal of structures. Place backfill that will support any portion of the roadbed or embankment to the same requirements for placing embankment. Backfill other areas in 10-in. layers, loose measurement, and compact to the density of adjacent undisturbed material.

496.3. Measurement. This Item will be measured by each structure or by the foot.

496.4. Payment. The work performed in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for “Removing Structures” of the type of structure specified. This price is full compensation for loading, hauling, disposal, stockpiling, removal of appurtenances, excavation and backfill, equipment, labor, tool, and incidentals.

ITEM 497

SALE OF SALVAGEABLE MATERIAL

497.1. Description. Salvage and remove from existing structures the structural steel, steel railing, or any other material designated for sale to the Contractor. Materials to be salvaged will be shown on the plans.

497.2. Construction. Salvage material for sale to the limits indicated on the plans or as required by other specifications. Remove all materials designated for sale from the project site before final acceptance of the project.

497.3. Measurement. All salvaged structural steel, steel railing, or other material designated for sale to the Contractor will be measured as a lump sum unit.

497.4. Payment. Salvaged material is a credit item to the Department and will be deducted from the Contractor’s monthly construction estimate upon completion of the removal.

510.4 to 512.3

510.4. Payment. Unless otherwise shown on the plans, the work performed and materials furnished in accordance with this Item will not be paid for directly but will be subsidiary to pertinent Items.

When shown on the plans as a bid item, the work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "One-Way Traffic Control." This price is full compensation for furnishing and operating equipment, pilot vehicle driver, flaggers, signs, labor, tools, and incidentals.

ITEM 512

PORTABLE CONCRETE TRAFFIC BARRIER

512.1. Description. Furnish, install, move, and remove portable precast concrete traffic barrier.

512.2. Materials. Barrier sections will be furnished by the Department when shown on the plans. Furnish new barrier using materials that meet the pertinent requirements of the following Items:

- Item 421, "Hydraulic Cement Concrete"
- Item 440, "Reinforcing Steel"
- Item 442, "Metal for Structures."

When temporary barrier is to be furnished and retained by the Contractor, products from nonapproved sources or previously used product may be provided if the Contractor submits written certification that the barrier sections and materials substantially conform to the requirements of this Item. The Engineer may approve the use of the product if:

- the barrier sections substantially meet typical cross-sectional dimension requirements,
- there is no evidence of structural damage such as major spalling or cracking, and
- the general condition of both the barrier sections and their connectors is acceptable.

Barrier sections to be furnished by the Department will be at a stockpile location or existing concrete traffic barrier installation shown on the plans.

512.3. Construction. Notify the Engineer of the location of the casting site and the date on which the work will begin. Multi-project fabrication plants (as defined in Item 424, "Precast Concrete Structures (Fabrication)") that produce concrete traffic barrier must be approved in accordance with DMS-7350, "Qualification Procedure for Multi-Project Fabrication Plants

512.3 to 512.4

of Precast Concrete Traffic Barrier.” The Construction Division maintains a list of approved multi-project plants. Construct barrier in accordance with Item 420, “Concrete Structures,” to the dimensions and cross-sections shown on the plans. Provide forms and cure concrete in accordance with Item 424, “Precast Concrete Structures (Fabrication).”

Provide a rough texture to the bottom surface of Single Slope, F Shape, or Safety Shape barriers and to the top of Low Profile barriers similar to a wood float finish.

Remove formwork after the concrete has reached sufficient strength to prevent physical damage to the member. When the barrier sections have attained sufficient strength to permit handling without causing visible damage, move the barrier sections to a storage area and place them on blocking to prevent damage.

Produce precast barrier to the tolerances given in Table 1 unless otherwise shown on the plans.

**Table 1
Precast Barrier Tolerances**

Dimension	Tolerance
Length	±1"
Insert Placement	±1/2"
Horizontal Alignment	±1/8" per 10 ft. of length
Deviation of Ends:	
Horizontal Skew	±1/4"
Vertical Batter	±1/8" per foot of depth

Install the barrier sections in accordance with the details shown on the plans or as directed.

Stockpile portable barriers no longer required on the project and to be retained by the Department, not designated for permanent use, at a site shown on the plans or as directed. Haul Department-owned connection hardware after use to the Department warehouse nearest the project unless otherwise shown on the plans or as directed.

Repair or replace all concrete traffic barrier or connecting hardware damaged by the Contractor’s operations at the Contractor’s expense.

Repair or replace any pavement damaged in the process of installing, moving, or removing barrier at the Contractor’s expense.

512.4. Measurement. This Item will be measured by the foot based on the nominal lengths of the barrier sections.

512.5 to 514.2

512.5. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for “Portable Concrete Traffic Barrier” of the work category (Furnish and Install, Designated Source, Move, Stockpile, or Remove), shape (e.g., Safety Shape, Single Slope, F Shape, or Low Profile) and type (1, 2, 3, etc.) of barrier specified. This price includes equipment, labor, tools, and incidentals.

- A. Furnish and Install.** This price is full compensation for furnishing and installing barrier and connection hardware.
- B. Designated Source.** This price is full compensation for delivering and installing Department-furnished barrier and connection hardware from a designated source.
- C. Move.** This price is full compensation for moving barrier installations on the project from one location to another (including disassembly and reassembly costs), moving barrier from an installation on the project to a temporary storage area (including disassembly costs), and moving barrier from a temporary storage area to an installation site on the project (including assembly costs).
- D. Stockpile.** This price is full compensation for removing barrier and connection hardware from the project and delivering to the Department stockpile area shown on the plans or as directed.
- E. Remove.** This price is full compensation for removing barrier and connection hardware from the project and retained by the Contractor.

ITEM 514

PERMANENT CONCRETE TRAFFIC BARRIER

514.1. Description. Construct permanent concrete traffic barrier.

514.2. Materials. Furnish new barrier using materials that meet the pertinent requirements of the following Items:

- Item 420, “Concrete Structures”
- Item 421, “Hydraulic Cement Concrete”
- Item 440, “Reinforcing Steel”
- Item 442, “Metal for Structures.”

Furnish the class of concrete shown on the plans.

533.4 to 536.2

Do not place shoulder texturing across exit or entrance ramps, acceleration and deceleration lanes, crossovers, gore areas, or intersections with other roadways, or at locations not shown on the plans. Correct misplaced texturing at the Contractor's expense.

A. Milled-In Shoulder Texturing. Provide milled-in shoulder texturing 7 in. wide in the direction of travel, with 1/2-in. tolerance, and 16 in. long perpendicular to travel. Construct depressions with a concave circular arc shape, a minimum depth of 1/2 in., and a maximum depth of 5/8 in. at the center of the cut. The depressions must have well defined edges and a smooth interior finish, and not snag or tear the finished pavement. Control dust during grinding operations.

Before opening the adjacent lane to traffic, remove and dispose of debris by vacuuming or sweeping as directed.

B. Rolled-In Shoulder Texturing. Perform texturing immediately behind the breakdown rolling operation and as closely behind the paver as possible. Construct shoulder texturing in a single pass. Do not allow vehicles or equipment on the textured area for a period of 24 hr. after texturing. Position rollers used for texturing by planking or other approved methods.

533.4. Measurement. Shoulder texturing will be measured longitudinally by the 100-ft. station. Measurement will not include interruptions across ramps, acceleration or deceleration lanes, crossovers, gore areas, or intersections with other roadways.

533.5. Payment. The work performed in accordance with this Item and measured as provided for under "Measurement" will be paid for at the unit price bid for "Shoulder Texturing (Milled)" and "Shoulder Texturing (Rolled)." This price is full compensation for equipment, labor, materials, tools, and incidentals.

ITEM 536

CONCRETE MEDIANS AND DIRECTIONAL ISLANDS

536.1. Description. Construct cast-in-place concrete medians and directional islands.

536.2. Materials. Furnish materials in accordance with the following:

- Item 420, "Concrete Structures"
- Item 421, "Hydraulic Cement Concrete"

536.3 to 538.1

- Item 440, “Reinforcing Steel”
- Item 529, “Concrete Curb, Gutter, and Combined Curb and Gutter.”

Use Class A concrete unless otherwise shown on the plans.

536.3. Construction. Provide wood or metal forms securely held in place. Properly position and secure reinforcing steel and dowels. Place concrete for each section on the prepared foundation to line, grade, and cross-section, in accordance with Item 420, “Concrete Structures.” Separate sections from adjacent curbs or adjoining sections using expansion or contraction joints of the type and size specified on the plans. A curb section may be used for the perimeter of the median or island when shown. Construct curbs in conformance with Item 529, “Concrete Curb, Gutter, and Combined Curb and Gutter.”

Finish exposed surfaces with a wood float after sufficient concrete set. Round exposed edges as shown on the plans.

Remove forms after concrete has set. Point up exposed surfaces. Provide an ordinary surface finish in accordance with Item 427, “Surface Finishes for Concrete.” Use mortar consisting of 1 part hydraulic cement and 2 parts fine aggregate to plaster exposed formed surfaces when required. Apply the mortar with a template made to conform to the cross-section shown on the plans.

Cure at least 72 hr. using a method specified in Item 420, “Concrete Structures.”

536.4. Measurement. This Item will be measured by the foot or by the square yard to the face of the curb.

536.5. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for “Concrete Median” or “Concrete Directional Island.” This price is full compensation for preparing foundation surfaces; furnishing and operating equipment; curbs and gutters used as part of the concrete median or directional island; and labor, materials, tools, and incidentals.

ITEM 538

RIGHT OF WAY MARKERS

538.1. Description. Install cast-in-place concrete right of way markers.

538.2 to 540.2

538.2. Materials. Provide Class A concrete in accordance with Item 421, “Hydraulic Cement Concrete,” and reinforcing steel in accordance with Item 440, “Reinforcing Steel.” The Department will furnish bronze disks.

538.3. Construction. Cast and finish right of way markers in accordance with Item 420, “Concrete Structures,” and details shown on the plans. Install right of way markers at designated points to the required horizontal and vertical locations. Center the bronze disk within 1/2 in. of the location shown. Reposition any marker that is outside this tolerance.

Unless otherwise shown on the plans, the Department will provide a survey crew working under the direction of a registered professional land surveyor, licensed to practice in Texas, to make the final alignment checks on each right of way marker installed and to place the right of way location punch mark on the bronze disk. Do not disturb or destroy the original points before installing right of way markers with bronze disks or before placing punch marks.

538.4. Measurement. This Item will be measured by each marker.

538.5. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for “Right of Way Markers.” This price includes materials, labor (including work of the registered professional land surveyor when required by the plans), tools, equipment, and incidentals. Removal and disposal of existing right of way markers will not be paid for directly but is subsidiary to pertinent Items.

ITEM 540

METAL BEAM GUARD FENCE

540.1. Description. Furnish and install, replace, or adjust metal beam guard fence consisting of metal beam rail element support on timber or steel posts.

540.2. Materials. When directed, provide samples of metal beam rail elements, terminal sections, bolts, and nuts for testing for compliance with the physical and chemical property requirements of AASHTO M 180 in accordance with Tex-708-I and Tex-713-I.

When the plans designate that the Department will furnish the materials, pick up the materials at the locations shown on the plans.

- A. Metal Beam Rail Elements.** Furnish new metal beam rail elements for rail and terminal anchor sections that meet the requirements of Table 1. Type I or II is allowed unless otherwise shown on the plans. Base metal for metal beam rail elements must not contain more than 0.04% phosphorous nor more than 0.05% sulfur.
- Furnish metal beam rail elements from approved manufacturers. A list of Department-approved manufacturers is maintained by the Construction Division.
- B. Posts.** Furnish new round timber, rectangular timber, or rolled steel section posts in accordance with details shown in the plans and the following requirements:
- 1. Timber Posts.** Meet the requirements of DMS-7200, "Timber Posts and Blocks for Metal Beam Guard Fence."
 - 2. Steel Posts.** Provide rolled sections conforming to the material requirements of ASTM A 36. Drill or punch posts for rail attachment as shown on the plans. Galvanize in accordance with Item 445, "Galvanizing."

Table 1
Rail Element Requirements

Specification	AASHTO M 180
Class	A – Base metal nominal thickness 0.105 in. \pm 0.008 in., or B – Base metal nominal thickness 0.135 in. \pm 0.008 in.
Type	I – Zinc-coated 1.80 ounces per square foot minimum single-spot, or II – Zinc-coated 3.60 ounces per square foot minimum single-spot. IV – Weathering Steel (required when shown on the plans).
Shape	W-beam or thrie beam or W-beam-to-thrie-beam transition.
Markings	Permanently mark each metal beam rail element with the information required in AASHTO M 180. Permanently mark all curved sections of metal beam rail element with the radius of the curved section in the format "R = xx ft." Markings (die-imprinted letters and numerals no more than 1/2 in. high) must be on the back of the metal beam rail section away from traffic and visible after erection.

- C. Blocks.** Furnish new rectangular timber or composite blocks in accordance with details shown in the plans and the following requirements:

540.3 to 540.3

1. **Timber.** Meet the requirements of DMS-7200, “Timber Posts and Blocks for Metal Beam Guard Fence.”
 2. **Composite.** Meet the requirements of DMS-7210, “Composite Material Posts and Blocks for Metal Beam Guard Fence.”
- D. Fittings.** Furnish new fittings (bolts, nuts, and washers) in accordance with the details shown on the plans and galvanized in accordance with Item 445, “Galvanizing.”
- E. Terminal Connectors.** Furnish new terminal connectors, where required, meeting the material and galvanizing requirements specified for metal beam rail elements.
- F. Concrete.** Furnish concrete for terminal anchor posts meeting the requirements for Class A concrete as required in Item 421, “Hydraulic Cement Concrete.”
- G. Curb.** If indicated in the details, furnish the curb shown with metal beam guard fence transition as required by Item 529, “Concrete Curb, Gutter, and Combined Curb and Gutter.”

540.3. Construction. Install posts and rail elements in accordance with the details shown on the plans.

- A. Posts.** Install posts by either drilling or driving.
1. **Drilling.** Drill holes and set posts plumb and firm to the line and grade shown. Backfill posts by thoroughly tamping the fill material in 4 in. layers.
 2. **Driving.** Drive posts plumb with approved power hammers (steam, compressed air, vibratory, or diesel) or gravity hammers to the line and grade shown. Use a structural steel driving head suitable for the type and size of post being driven with wood cushion blocks as necessary to prevent damage to the post. Rope mat, belting, or other similar cushioning material may be used in addition to wood cushion blocks. Use pilot holes when required or permitted. Determine the size and depth of pilot holes with the approval of the Engineer based on results of trial operations of the first few posts driven. Thoroughly tamp loosened soil around the post, fill with suitable material any void between the soil and the post resulting from the driving, and thoroughly compact to the density of adjacent undisturbed material.
- B. Rail Elements.** Erect metal beam rail elements to produce a smooth, continuous rail paralleling the line and grade of the roadway surface or as shown on the plans. Bolt rail elements end to end and lap in the

When Schedule 3 is specified, no associated bonuses will be paid for any 0.1-mi. section that contains localized roughness.

- b. IRI Deficient 0.1-mi. Sections.** When pay adjustment Schedule 1 or 2 is specified, use diamond grinding or other approved work methods to correct any 0.1-mi. section with an average IRI over 95.0 in. per mile (IRI deficient). Correct the deficient section to an IRI of 65 in. per mile or less when Schedule 1 is specified and to an IRI of 75 in. per mile or less when Schedule 2 is specified. After making corrections, reprofile the pavement section to verify that corrections have produced the required improvements. Associated bonuses apply when successful corrective action improves the IRI of a deficient 0.1-mi. section.
- (1) **Hydraulic Concrete Pavement.** Use diamond grinding to correct deficient 0.1-mi. sections.
 - (2) **Asphalt Concrete Pavement.** For asphalt concrete pavement, the Engineer may assess a \$3,000 penalty per 0.1-mi. section instead of requiring corrective action. Use diamond grinding or other approved methods to correct deficient 0.1-mi. sections. If corrective action does not produce the required improvement, the Engineer may require continued corrective action, assess the pertinent schedule penalty if the reprofiled IRI is 95 in. per mile or less, or assess the \$3,000 penalty if the reprofiled IRI is greater than 95 in. per mile. Fog seal the aggregate exposed from diamond grinding or other corrective methods allowed.
- c. Localized Roughness.** Localized roughness will be measured using an inertial profiler in accordance with Tex-1001-S. The Engineer will determine areas of localized roughness using the average profile from both wheel paths.
- The Engineer may waive localized roughness requirements for deficiencies resulting from manholes or other similar appurtenances near the wheel path.
- (1) **Corrective Action.** When Schedule 1 or 2 is specified, use diamond grinding or other approved methods to remove localized roughness.
- When Schedule 3 is specified, use a 10-ft. straightedge to further evaluate areas with localized roughness, and use

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diamond grinding or other approved methods to correct areas that have more than 1/8-in. variation between any 2 contacts on the straightedge.

For asphalt concrete pavements, fog-seal the aggregate exposed from diamond grinding.

Reprofile the corrected area, and provide the Engineer the results that show the corrective action was successful. For asphalt concrete pavement, if the corrective action is not successful, the Engineer will require continued corrective action or assess a localized roughness penalty.

- (2) **Localized Roughness Penalty Assessed.** For asphalt concrete pavement, in lieu of corrective action, the Engineer may assess a penalty for each occurrence of localized roughness. No more than 1 penalty will be assessed for any 5 ft. of longitudinal distance. No localized roughness penalties will be assessed in deficient 0.1-mi. sections where the Engineer elects to assess the \$3,000 penalty instead of corrective action. For Schedule 1, a localized roughness penalty of \$500 per occurrence will be assessed. For Schedule 2, a localized roughness penalty of \$250 per occurrence will be assessed. For Schedule 3, localized roughness penalties will not be assessed.

585.4. Measurement and Payment. The work performed, materials furnished, certification and recertification, traffic control for all testing, materials and work needed for corrective action, equipment, labor, tools, and incidentals will not be measured or paid for directly but will be subsidiary to pertinent Items. Sections shorter than 0.1 mi. and longer than 50 ft. will be prorated in accordance with Tex-1001-S.

Table 1
Pay Adjustment Schedules for Ride Quality

Average IRI for each 0.10 mi. of Traffic Lane (in. / mi.)	Pay Adjustment \$/0.10 mi. of Traffic Lane		
	Schedule 1	Schedule 2	Schedule 3
< 30	600	600	300
30	600	600	300
31	580	580	290
32	560	560	280
33	540	540	270
34	520	520	260
35	500	500	250
36	480	480	240
37	460	460	230
38	440	440	220
39	420	420	210
40	400	400	200
41	380	380	190
42	360	360	180
43	340	340	170
44	320	320	160
45	300	300	150
46	280	280	140
47	260	260	130
48	240	240	120
49	220	220	110
50	200	200	100
51	180	180	90
52	160	160	80
53	140	140	70
54	120	120	60
55	100	100	50
56	80	80	40
57	60	60	30
58	40	40	20
59	20	20	10
60	0	0	0
61	0	0	0

644.1 to 644.3

ITEM 644

SMALL ROADSIDE SIGN SUPPORTS AND ASSEMBLIES

644.1. Description.

- **Installation.** Furnish, fabricate, and erect small roadside sign assemblies consisting of the signs, sign supports, foundations, and associated mounting hardware.
- **Relocation.** Relocate existing small roadside sign assemblies, and furnish and fabricate materials as required.
- **Removal.** Remove existing small roadside sign assemblies.

644.2. Materials. Furnish all materials unless otherwise shown on the plans. Furnish only new materials. Furnish and fabricate materials in accordance with the following Items and with details shown on the plans:

- Item 421, "Hydraulic Cement Concrete"
- Item 440, "Reinforcing Steel"
- Item 441, "Steel Structures"
- Item 442, "Metal for Structures"
- Item 445, "Galvanizing"
- Item 634, "Plywood Signs"
- Item 636, "Aluminum Signs"
- Item 643, "Sign Identification Decals"
- Item 656, "Foundations for Traffic Control Devices."

Use galvanized steel, stainless steel, dichromate sealed aluminum, or other materials shown on the plans for pipe, bolts, nuts, washers, lock washers, screws, and other sign assembly hardware. When dissimilar metals are used, select or insulate the metals to prevent corrosion.

644.3. Construction. Install foundations in accordance with Item 656, "Foundations for Traffic Control Devices." Plumb sign supports. Do not spring or rake posts to secure proper alignment. Use established safety practices when working near underground or overhead utilities. Consult the appropriate utility company before beginning work.

- A. Fabrication.** Fabricate sign supports in accordance with Item 441, "Steel Structures." Ensure that all components fit properly.

Verify the length of each post for each sign before fabrication to meet field conditions and sign-mounting heights shown on the plans.

Galvanize fabricated parts in accordance with Item 445, "Galvanizing." Punch or drill any holes in steel parts or members before the parts or members are galvanized. Repair any steel part or member on which the

galvanizing has been damaged during assembly, transit, erection, or welding in accordance with Section 445.3.D, "Repairs."

- B. Installation.** Locate sign supports as shown on the plans, unless directed to shift the sign supports within design guidelines to secure a more desirable location or to avoid conflict with utilities and underground appurtenances. Stake sign-support locations for verification by the Engineer.

Install stub posts of the type, spacing, orientation, and projection shown on the plans. Remove and replace posts damaged during installation at the Contractor's expense.

Connect the upper post sections to the stub post sections as shown on the plans. Torque connection bolts as shown on the plans.

Attach signs to support assemblies in accordance with the plans and pertinent Items.

- C. Relocation.** Unless otherwise shown on the plans, reuse the existing supports and shorten or lengthen them as required. Obtain approval before lengthening existing supports. Furnish and install new breakaway stub posts in new foundations for relocated signs. Erect the supports on the new breakaway stub posts, and attach the signs to the supports. Attach signs to support assemblies in accordance with the plans and pertinent Items. Remove existing foundations to be abandoned in accordance with Section 644.3.D, "Removal."
- D. Removal.** Remove existing concrete foundations that are to be abandoned to 2 ft. below finish grade. Backfill the remaining hole with material equal in composition and density to the surrounding area. Replace any surfacing with like material to equivalent condition.
- E. Handling and Storage.** Handle and store existing signs or portions of signs removed so that they are not damaged. Prevent any damage to the various sign assembly components. Replace any portion of the sign damaged by the Contractor designated for reuse or salvage, including messages removed.
- Stockpile all removed sign components that will be reused or that become the property of the Department at designated locations. Accept ownership of unsalvageable materials, and dispose of them in accordance with federal, state, and local regulations.
- F. Cleaning.** After the sign has been installed, wash the entire sign with a biodegradable cleaning solution acceptable to the sheeting and screen ink manufacturers to remove dirt, grease, oil smears, streaks, finger marks, and other foreign materials.

644.4 to 647.1

644.4. Measurement. This Item will be measured as each small roadside assembly installed, removed, or relocated.

644.5. Payment. The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for “Install Small Roadside Sign Supports and Assemblies” of the type specified, “Relocate Small Roadside Sign Supports and Assemblies” of the type specified, or “Remove Small Roadside Sign Supports and Assemblies.”

- A. Installation.** This price is full compensation for furnishing, fabricating, galvanizing, and erecting the supports; constructing foundations including concrete (when required); furnishing complete signs including sign connections and all hardware; attaching the signs to the supports; washing and cleaning the signs; and equipment, materials, labor, tools, and incidentals.
- B. Relocation.** This price is full compensation for furnishing and installing new breakaway stubs and new sign supports (when required); constructing foundations including concrete (when required); removing existing signs and related materials; new signs (when required); modifying existing sign supports; reinstallation of signs and sign assemblies; preparing and cleaning; salvaging; disposal of unsalvageable material; hauling, excavating, backfilling, and surface placement; new hardware; and equipment, materials, labor, tools, and incidentals.
- C. Removal.** This price is full compensation for removing existing sign assemblies and related materials; salvaging; disposal of unsalvageable material; hauling, excavating, backfilling, and surface placement; and equipment, materials, labor, tools, and incidentals.

ITEM 647

LARGE ROADSIDE SIGN SUPPORTS AND ASSEMBLIES

647.1. Description.

- **Installation.** Furnish, fabricate, and erect steel supports for large roadside signs.
- **Relocation.** Relocate existing large roadside sign assemblies, and furnish and fabricate materials as required.
- **Removal.** Remove existing large roadside sign assemblies.

686.3 to 686.3

- Item 442, “Metal for Structures”
- Item 445, “Galvanizing”
- Item 449, “Anchor Bolts.”

Furnish alloy steel or medium-strength mild steel anchor bolts in accordance with Item 449.2.A, “Bolts and Nuts.”

686.3. Construction.

- A. Standard Design.** Alternate designs are not acceptable. Deviations that affect the basic structural behavior of the pole are considered to be alternate designs. For deviations that do not affect the basic structural behavior of the pole, submit 7 sets of shop drawings to the Bridge Division for approval.
- B. Fabrication.** Fabricate and weld in accordance with Item 441, “Steel Structures”; AWS D1.1, *Structural Welding Code—Steel*; and the requirements of this Item. Fabrication tolerances are given in Table 1.

**Table 1
Fabrication Tolerances**

Part	Dimension	Tolerance (in.)
Pole and mast arm shaft	Length	±1
	Thickness	+0.12, -0.02
	Difference between flats or diameter	±3/16
	Straightness	1/8 in 10 ft.
	Attachment locations	±1
Base and mast arm mounting plates	Overall	±3/16
	Thickness	+1/4, -0
	Deviations from flat	3/16 in 24 in.
	Spacing between holes	±1/8
	Bolt hole size	±1/16
Anchor bolts	Length	±1/2
	Threaded Length	±1/2
	Galvanized Length	-1/4
Assembled shafts	Angular Orientation	1/16 in 12 in. ¹
	Centering	±3/16
	Twist	3° in 50 ft.

1. 1/8 in 12 in. between mounting plates and between mounting plates and base plates.

Provide properly fitting components. Provide round or octagonal shafts for poles and mast arms tapered as shown on the plans. Fabricate mast arms straight in the unloaded condition unless otherwise shown on the

plans. The Department will accept bolted slip joints overlapping by at least 1.5 diameters in mast arms 40 ft. and longer.

Provide circumferential welds only at the ends of the shafts. Provide no more than 2 longitudinal seam welds in shaft sections. Grind or smooth the exterior of longitudinal seam welds to the same appearance as other shaft surfaces. Ensure 100% penetration within 6 in. of circumferential base welds and at least 60% penetration at other locations along the longitudinal seam welds. Use a welding technique that minimizes acid entrapment during later galvanizing. Hot-dip galvanize all fabricated parts in accordance with Item 445, "Galvanizing."

Treat welds with Ultrasonic Impact Treatment as shown on the plans after galvanization and with the dead load (actual or simulated) applied. Repair damaged galvanizing in accordance with Section 445.3.D, "Repairs."

Connect the luminaire arm to the pole with simplex fittings. Ensure the fittings have no defects affecting strength or appearance.

Ensure that the design wind speed is identified and permanently visible on the pole base plate and mast arm mounting plate.

Deliver each traffic signal pole assembly with fittings and hardware either installed or packaged with its associated components. Ship all components with a weatherproof tag identifying the manufacturer, contract number, date, and destination of shipment.

- C. Installation.** Locate traffic signal poles as shown on the plans unless otherwise directed to secure a more desirable location or to avoid conflict with utilities. Stake the traffic signal pole locations for verification by the Engineer.

Construct foundations in accordance with Item 416, "Drilled Shaft Foundations." Orient anchor bolts as shown on the plans.

Use established industry and utility safety practices when working near underground or overhead utilities. Consult with the appropriate utility company before beginning such work.

Erect structures after foundation concrete has attained its design strength as required in the plans and Item 421, "Hydraulic Cement Concrete." Coat anchor bolt threads and tighten anchor bolts in accordance with Item 449, "Anchor Bolts."

After the traffic signal pole assembly is plumb and all nuts are tight, tack-weld each anchor bolt nut in 2 places to its washer. Tack-weld each washer to the base plate in 2 places. Do not weld components to