City of Houston - Department of Aviation – Infrastructure Division

PROJECT MANUAL

Will Clayton to JFK Flyover Bridge Reconstruction
George Bush Intercontinental Airport (IAH)

PROJECT No.: 931

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VOLUME NO. 1 OF 1 TOTAL VOLUMES

TxDOT Specifications

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Item 100
Preparing Right of Way

1. DESCRIPTION

Prepare the right of way and designated easements for construction operations by removing and disposing of all obstructions when removal of such obstructions is not specifically shown on the plans to be paid by other Items.

2. CONSTRUCTION

Protect designated features on the right of way and prune trees and shrubs as directed. Do not park equipment, service equipment, store materials, or disturb the root area under the branches of trees designated for preservation. Treat cuts on trees with an approved tree wound dressing within 20 min. of making a pruning cut or otherwise causing damage to the tree when shown on the plans. Follow all local and state regulations when burning. Pile and burn brush at approved locations as directed. Coordinate work with state and federal authorities when working in state or national forests or parks. Test, remove, and dispose of hazardous materials in accordance with Article 6.10., "Hazardous Materials."

Clear areas shown on the plans of all obstructions, except those landscape features that are to be preserved. Such obstructions include remains of houses and other structures, foundations, floor slabs, concrete, brick, lumber, plaster, septic tank drain fields, basements, abandoned utility pipes or conduits, equipment, fences, retaining walls, and other items as specified on the plans. Remove vegetation and other landscape features not designated for preservation, curb and gutter, driveways, paved parking areas, miscellaneous stone, sidewalks, drainage structures, manholes, inlets, abandoned railroad tracks, scrap iron, and debris, whether above or below ground. Removal of live utility facilities is not included in this Item. Remove culverts, storm sewers, manholes, and inlets in proper sequence to maintain traffic and drainage.

Notify the Engineer in writing when items not shown on the plans and not reasonably detectable (buried with no obvious indication of presence) are encountered and required to be removed. These items will be handled in accordance with Article 4.5., "Differing Site Conditions."

Remove obstructions not designated for preservation to 2 ft. below natural ground in areas receiving embankment. Remove obstructions to 2 ft. below the excavation level in areas to be excavated. Remove obstructions to 1 ft. below natural ground in all other areas. Cut trees and stumps off to ground level when allowed by the plans or directed. Plug the remaining ends of abandoned underground structures over 3 in. in diameter with concrete to form a tight closure. Backfill, compact, and restore areas where obstructions have been removed unless otherwise directed. Use approved material for backfilling. Dispose of wells in accordance with Item 103, "Disposal of Wells."

Accept ownership, unless otherwise directed, and dispose of removed materials and debris at locations off the right of way in accordance with local, state, and federal requirements.

3. MEASUREMENT

This Item will be measured by the acre; by the 100-ft. station, regardless of the width of the right of way; or by each tree removed.

4. PAYMENT

For "acre" and "station" measurement, the work performed in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Preparing Right of Way." For "each"

measurement, the work performed in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Preparing Right of Way (Tree)" of the diameter specified. This price is full compensation for pruning of designated trees and shrubs; removal and disposal of structures and obstructions; backfilling of holes; furnishing and placing concrete for plugs; and equipment, labor, tools, and incidentals.

Total payment of this Item will not exceed 10% of the original contract amount until final acceptance. The remainder will be paid on the estimate after the final acceptance under Article 5.12., "Final Acceptance."

Item 104
Removing Concrete

1. DESCRIPTION

Break, remove, and salvage or dispose of existing hydraulic cement concrete.

2. CONSTRUCTION

Remove existing hydraulic cement concrete from locations shown on the plans. Avoid damaging concrete that will remain in place. Saw-cut and remove the existing concrete to neat lines. Replace any concrete damaged by the Contractor at no expense to the Department. Accept ownership and properly dispose of broken concrete in accordance with federal, state, and local regulations unless otherwise shown on the plans.

3. MEASUREMENT

Removing concrete pavement, floors, porches, patios, riprap, medians, foundations, sidewalks, driveways, and other appurtenances will be measured by the square yard (regardless of thickness) or by the cubic yard of calculated volume, in its original position.

Removing curb, curb and gutter, and concrete traffic barrier will be measured by the foot in its original position. The removal of monolithic concrete curb or dowelled concrete curb will be included in the concrete pavement measurement.

Removing retaining walls will be measured by the square yard along the front face from the top of the wall to the top of the footing.

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.

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 “Removing Concrete” of the type specified. This price is full compensation for breaking the concrete; loading, hauling, and salvaging or disposing of the material; and equipment, labor, tools, and incidentals.

Removing retaining wall footings will not be paid for directly but will be considered subsidiary to this Item.

Item 105

Removing Treated and Untreated Base and Asphalt Pavement

1. DESCRIPTION

Break, remove, and store or dispose of existing asphalt pavement, including surface treatments, and treated or untreated base materials.

2. CONSTRUCTION

Break material retained by the Department into pieces not larger than 24 in. unless otherwise shown on the plans. Remove existing asphalt pavement before disturbing stabilized base. Avoid contamination of the asphalt materials and damage to adjacent areas. Repair material damaged by operations outside the designated locations.

Stockpile materials designated salvageable at designated sites when shown on the plans or as directed. Prepare stockpile site by removing vegetation and trash and by providing for proper drainage. Material not designated to be salvaged will become the property of the Contractor. When this material is disposed of, do so in accordance with federal, state, and local regulations.

3. MEASUREMENT

This Item will be measured by the 100-ft. station along the baseline of each roadbed, by the square yard of existing treated or untreated base and asphalt pavement in its original position, or by the cubic yard of existing treated or untreated base and asphalt pavement in its original position, as calculated by the average end area method. Square yard and cubic yard measurement will be established by the widths and depths shown on the plans and the lengths measured in the field.

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 Treated and Untreated Base and Asphalt Pavement” of the depth specified. This price is full compensation for breaking the material, loading, hauling, unloading, stockpiling or disposing; repair to areas outside designated locations for removal; and equipment, labor, tools, and incidentals.

Item 251
Reworking Base Courses

1. DESCRIPTION

Refinish or rework existing base material with or without asphaltic concrete pavement. Incorporate new base material when shown on the plans.

2. MATERIALS

Furnish uncontaminated materials of uniform quality that meet the requirements of the plans and specifications. Notify the Engineer of the proposed material sources and of changes to material sources. The Engineer will verify that the specification requirements are met before the sources can be used. The Engineer may sample and test project materials at any time before compaction. Use Tex-100-E for material definitions.

2.1. **Flexible Base**. Furnish new base material that meets the requirements of Item 247, "Flexible Base," for the type and grade shown on the plans.

2.2. **Water**. Furnish water free of industrial wastes and other objectionable matter.

3. EQUIPMENT

Provide machinery, tools, and equipment necessary for proper execution of the work.

3.1. **Compaction Equipment**. Provide rollers in accordance with Item 210, "Rolling." Provide rollers in accordance with Item 216, "Proof Rolling," when required.

3.2. **Pulverization Equipment**. Provide pulverization equipment that:

- cuts and pulverizes material uniformly to the proper depth with cutters that plane to a uniform surface over the entire width of the cut,
- provides a visible indication of the depth of cut at all times, and
- uniformly mixes the materials.

4. CONSTRUCTION

Perform work to the width and depth shown on the typical sections for the type of work shown on the plans. Construct and shape exposed subgrade to conform to typical sections as shown on the plans or as directed. Proof roll in accordance with Item 216, "Proof Rolling," when shown on the plans. Correct soft spots as directed.

Before scarifying, clean the existing base of objectionable materials by blading, brooming, or other approved methods, unless otherwise shown on the plans. Perform this work in accordance with applicable Items.

4.1. **Types of Work**.

4.1.1. **Type A**. Scarifying only.

4.1.2. **Type B**. Scarifying, salvaging, and re-laying.

4.1.3. **Type C**. Scarifying and reshaping.

4.1.4. **Type D**. Refinishing.

4.2. **Performance of Work**.

4.2.1. **Scarifying**. Loosen and break existing base material, with or without existing asphaltic concrete pavement. Remove asphalt concrete pavement, surface treatment, plant-mix seal, and micro-surfacing when shown on the plans and in accordance with applicable items. Prevent contamination of asphalt material during and after removal. When the existing pavement consists of only a surface treatment, do not remove before scarifying. Scarify existing material for its full width and depth unless otherwise shown on the plans. Do not disturb the underlying subgrade. Break material into particles of not more than 2-1/2 in. unless otherwise shown on the plans.

4.2.2. **Salvaging**. Remove the existing base material and stockpile. Windrow if allowed. Perform salvage operations without interfering with traffic, proper drainage, or the general requirements of the work. Remove scarified material using a method approved by the Engineer. Keep material free of contamination.

4.2.3. **Re-Laying**. Prepare subgrade as shown on the plans or as directed before relaying salvaged material. Proof roll in accordance with Item 216, “Proof Rolling,” when shown on the plans. Correct soft spots as directed.

Return and rework salvaged base material, with or without additional new base material, on the prepared roadbed. Place salvaged material on the prepared subgrade and sprinkle, blade, and shape the base to conform to the typical sections shown on the plans or as directed. Place new base material and uniformly mix with salvaged material when shown on the plans. Correct, or remove and replace, segregated material with satisfactory material, as directed.

4.2.4. **Reshaping**. Rework scarified base material with or without additional new base material. Mix and shape scarified base to conform to the typical sections shown on the plans. When shown on the plans, furnish new base material, and uniformly mix with scarified material before shaping. Do not disturb the underlying subgrade. Correct, or remove and replace, segregated material with satisfactory material as directed.

4.2.5. **Refinishing**. Blade existing base surface to remove irregularities. Cure before placing the pavement on the refinished base, as shown on the plans or as directed.

4.3. **Compaction**. Compact using ordinary compaction or density control as shown on the plans. Bring each layer to the moisture content directed. When necessary, sprinkle the material in accordance with Item 204, “Sprinkling.”

Begin rolling longitudinally at the sides and proceed toward the center, overlapping on successive trips by at least one-half the width of the roller unit. On superelevated curves, begin rolling at the low side and progress toward the high side. Offset alternate trips of the roller. Operate rollers at a speed between 2 and 6 mph, as directed.

Rework, recompact, and refinish material that fails to meet or that loses required moisture, density, stability, or finish before the next course is placed or the project is accepted. Continue work until specification requirements are met. Perform the work at no additional expense to the Department.

4.3.1. **Ordinary Compaction**. Roll with approved compaction equipment as directed. Correct irregularities, depressions, and weak spots immediately by scarifying the areas affected, adding or removing approved material as required, reshaping, and recompacting.

4.3.2. **Density Control**. Determine the moisture content in the mixture at the beginning of and during compaction in accordance with Tex-103-E. Compact to at least 98% of the maximum density determined by Tex-113-E, unless otherwise shown on the plans.

The Engineer will determine roadway density of completed sections in accordance with Tex-115-E. The Engineer may accept the section if no more than 1 of the 5 most recent density tests is below the specified density and the failing test is no more than 3 pcf below the specified density.

4.4. **Finishing**. Immediately after completing compaction, clip, skin, or tight-blade the surface with a maintainer or subgrade trimmer to a depth of approximately 1/4 in. Remove and dispose of loosened material at an approved location. Seal the clipped surface immediately by rolling with a pneumatic tire roller until a smooth surface is attained. Add small amounts of water as needed during rolling. Shape and maintain the course and surface in conformity with the typical sections, lines, and grades shown on the plans or as directed.

In areas where surfacing is to be placed, correct grade deviations in excess of 1/4 in. in 16 ft. measured longitudinally for the entire width of the cross-section. Correct by loosening, adding, or removing material. Reshape and recompact in accordance with Section 251.4.3., "Compaction."

4.5. **Curing**. Cure the finished section until the moisture content is at least 2% below optimum or as directed before applying the next successive course or prime coat.

5. MEASUREMENT

This Item will be measured by the station, square yard, cubic yard, or ton.

Square yard and cubic yard in original position measurement will be established by the widths and depths shown on the plans and the lengths measured in the field.

When material is measured in trucks, the weight of the material will be determined on certified scales, or the Contractor must provide a set of standard platform truck scales at a location approved by the Engineer. Scales must conform to the requirements of Item 520, "Weighing and Measuring Equipment."

Measurement is further defined for payment as follows.

5.1. **Station**. By the 100-ft. station measured along the centerline of each roadbed.

5.2. **Square Yard**. By the square yard of existing base or pavement in its original position. When square yard measurement is used, limits of measurement will be as shown on the plans.

5.3. **Cubic Yard in Vehicle**. By the cubic yard of salvaged material in vehicles as delivered at the stockpile.

5.4. **Cubic Yard in Stockpile**. By the cubic yard of salvaged material in the final stockpile position by the method of average end areas.

5.5. **Cubic Yard in Original Position**. By the cubic yard in its original position measured by the method of average end areas.

5.6. **Ton**. By the ton of dry weight in the trucks as delivered at the stockpile. The dry weight is determined by deducting the weight of the moisture in the material at the time of weighing from the gross weight of the material. The Engineer will determine the moisture content in the material in accordance with Tex-103-E from samples taken at the time of truck weighing.

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 "Reworking Base Material" for the type, scarified depth, and compaction method shown on the plans. For cubic yard measurements, the measurement location (vehicle, stockpile, or original position) will be specified. No additional payment will be made for thickness or width exceeding that shown on the typical sections or provided on the plans for station, square yard, and cubic yard in the original position measurement. This price is full compensation for furnishing and

disposing of materials, blading, brooming, scarifying, salvaging, replacing, stockpiling, reshaping, refinishing, compacting, finishing, curing, and equipment, labor, tools, and incidentals.

Furnishing and delivering new base will be paid for in accordance with Section 247.6.2., “Flexible Base (Roadway Delivery).” Mixing, spreading, blading, shaping, compacting, and finishing new or existing base material will not be paid for directly but will be subsidiary to this Item.

Sprinkling and rolling, except proof rolling, will not be paid for directly but will be subsidiary to this Item, unless otherwise shown on the plans. When proof rolling is shown on the plans or directed by the Engineer, it will be paid for in accordance with Item 216, “Proof Rolling.”

Where subgrade is constructed under this Contract, correction of soft spots in the subgrade or existing base will be at the Contractor’s expense. Where subgrade is not constructed under this Contract, correction of soft spots in the subgrade or existing base will be in accordance with pertinent Items or Article 4.4., “Changes in the Work.”

Removal of existing asphalt concrete pavement will be paid for in accordance with pertinent Items or Article 4.4., “Changes in the Work.”

Additional restrictions for measurement and payment are as follows:

- **Type A**. Work will be restricted to station and square yard measurement.
- **Type B**. Work will be restricted to station, square yard, and cubic yard in the original position measurement.
- **Type C**. Work will be restricted to station, square yard, and cubic yard in the original position measurement.
- **Type D**. Work will be restricted to station and square yard measurement.

Item 275
Cement Treatment (Road-Mixed)

1. DESCRIPTION

Mix and compact cement, water, and subgrade or base (with or without asphalt concrete pavement) in the roadway.

2. MATERIALS

Furnish uncontaminated materials of uniform quality that meet the requirements of the plans and specifications. Notify the Engineer of the proposed material sources and of changes to material sources. The Engineer will verify that the specification requirements are met before the sources can be used. The Engineer may sample and test project materials at any time before compaction. Use Tex-100-E for material definitions.

2.1. **Cement**. Furnish hydraulic cement that meets the requirements of DMS-4600, "Hydraulic Cement," and the Department's *Hydraulic Cement Quality Monitoring Program* (HCQMP). Sources not on the HCQMP will require testing and approval before use.

2.2. **Subgrade**. The Engineer will determine the sulfate content in accordance with Tex-145-E and organic content in accordance with Tex-148-E before cement treatment begins. Suspend operations when material to be treated has a sulfate content greater than 7,000 ppm or an organic content greater than 1.0% and proceed as directed.

2.3. **Flexible Base**. Unless otherwise shown on the plans, furnish base material that meets the requirements of Item 247, "Flexible Base," for the type and grade shown on the plans, before the addition of cement.

2.4. **Water**. Furnish water free of industrial waste and other objectionable material.

2.5. **Asphalt**. When permitted for curing purposes, furnish asphalt or emulsion that meets the requirements of Item 300, "Asphalts, Oils, and Emulsions," as shown on the plans or directed.

2.6. **Mix Design**. The Engineer will determine the target cement content and optimum moisture content to produce a stabilized mixture that meets the strength requirements shown on the plans. The mix will be designed in accordance with Tex-120-E or will be based on prior experience with the project materials. The Contractor may propose a mix design developed in accordance with Tex-120-E. Meet strength requirements when shown on the plans. The Engineer will use Tex-120-E to verify the Contractor's proposed mix design before acceptance. Reimburse the Department for subsequent mix designs or partial designs necessitated by changes in the material or requests by the Contractor. Limit the amount of recycled asphalt pavement to no more than 50% of the mix unless otherwise shown on the plans or directed.

3. EQUIPMENT

Provide machinery, tools, and equipment necessary for proper execution of the work. Provide rollers in accordance with Item 210, "Rolling." Provide proof rollers in accordance with Item 216, "Proof Rolling," when required.

3.1. **Cement Storage Facility**. Store cement in closed, weatherproof containers.

3.2. **Cement Slurry Equipment**. Use slurry tanks equipped with agitation devices to slurry cement on the project or other approved location. The Engineer may approve other slurrying methods. Provide a pump for agitating

the slurry when the distributor truck is not equipped with an agitator. Equip the distributor truck with an approved sampling device.

3.3. **Dry Cement Distribution Equipment**. Provide equipment to spread cement evenly across the area to be treated. Provide equipment with a rotary vane feeder when shown on the plans.

3.4. **Pulverization Equipment**. Provide pulverization equipment that:

- cuts and pulverizes material uniformly to the proper depth with cutters that will plane to a uniform surface over the entire width of the cut,
- provides a visible indication of the depth of cut at all times, and
- uniformly mixes the materials.

4. CONSTRUCTION

Construct each layer uniformly, free of loose or segregated areas and with the required density and moisture content. Provide a smooth surface that conforms to the typical sections, lines, and grades shown on the plans or as directed.

4.1. **Preparation of Subgrade or Existing Base for Treatment**. Before treating, remove existing asphalt concrete pavement in accordance with pertinent Items and the plans or as directed. Shape existing material in accordance with applicable bid items to conform to the typical sections shown on the plans and as directed.

When shown on the plans or directed, proof roll the roadbed in accordance with Item 216, “Proof Rolling,” before pulverizing or scarifying existing material. Correct soft spots as directed.

Provide the borrow source location well in advance when material is imported, to allow time for testing and approval to avoid delay to the project. Stockpile as directed. The Engineer will test the borrow source and determine the sulfate and organic contents. When the borrow source has a sulfate content greater than 3,000 ppm or an organic content greater than 1.0%, proceed as directed.

When new base is required to be mixed with existing base, deliver, place, and spread the new material in the required amount per station. Manipulate and thoroughly mix new base with existing material to provide a uniform mixture to the specified depth before shaping.

4.2. **Pulverization**. Pulverize or scarify existing material after shaping so that 100% passes a 2-1/2 in. sieve. If the material cannot be uniformly processed to the required depth in a single pass, excavate and windrow the material to expose a secondary grade to achieve processing to plan depth.

4.3. **Application of Cement**. Uniformly apply cement using dry placement unless otherwise shown on the plans. Add cement at the percentage determined in Section 275.2.6., “Mix Design.” Apply cement only on an area where mixing, compacting, and finishing can be completed during the same working day.

Start cement application only when the air temperature is at least 35°F and rising or is at least 40°F. The temperature will be taken in the shade and away from artificial heat. Suspend application when the Engineer determines that weather conditions are unsuitable.

4.3.1. **Dry Placement**. Before applying cement, bring the prepared roadway to approximately optimum moisture content. When necessary, sprinkle in accordance with Item 204, “Sprinkling.” Distribute the required quantity of dry cement with approved equipment. Minimize dust and scattering of cement by wind. Do not apply cement when wind conditions, in the opinion of the Engineer, cause blowing cement to become dangerous to traffic or objectionable to adjacent property owners.

4.3.2. **Slurry Placement**. Mix the required quantity of cement with water, as approved. Provide slurry free of objectionable materials and with a uniform consistency that can be easily applied. Agitate the slurry

continuously. Apply slurry within 2 hours of adding water and when the roadway is at a moisture content drier than optimum. Distribute slurry uniformly by making successive passes over a measured section of the roadway until the specified cement content is reached.

4.4. **Mixing**. Thoroughly mix the material and cement using approved equipment. Mix until a homogeneous mixture is obtained. Sprinkle the treated materials during the mixing operation, as directed, to maintain optimum mixing moisture. Spread and shape the completed mixture in a uniform layer.

After mixing, the Engineer may sample the mixture at roadway moisture and test in accordance with Tex-101-E, Part III, to determine compliance with the gradation requirements in Table 1. When strength requirements are shown on the plans, the Engineer may sample the mixture to verify strength in accordance with Tex-120-E and adjust cement content to achieve the target strength for work going forward.

Table 1
Gradation Requirements Minimum % Passing

Sieve Size	Base	Subgrade
1-3/4"	100	100
3/4"	85	85
#4	–	60

4.5. **Compaction**. Compact the mixture in one lift using density control unless otherwise shown on the plans. Complete compaction within 2 hours after the application of water to the mixture of material and cement.

Sprinkle the treated material in accordance with Item 204, “Sprinkling,” or aerate the treated material to adjust the moisture content during compaction so that it is within 2.0 percentage points of optimum as determined by Tex-120-E. Measure the moisture content of the material in accordance with Tex-115-E or Tex-103-E during compaction daily and report the results the same day to the Engineer, unless otherwise shown on the plans or directed. Adjust operations as required.

Begin rolling longitudinally at the sides and proceed towards the center, overlapping on successive trips by at least one-half the width of the roller unit. On superelevated curves, begin rolling at the low side and progress toward the high side. Offset alternate trips of the roller. Operate rollers at a speed between 2 and 6 mph, as directed.

Before final acceptance, the Engineer will select the locations of tests in each unit and measure the treated depth in accordance with Tex-140-E. Correct areas deficient by more than 1/2 in. in thickness or more than 1/2% in target cement content by adding cement as required, reshaping, re-compacting, and refinishing at the Contractor’s expense.

Remove or rework areas that lose required stability, compaction, or finish, as directed. When a section is reworked more than 4 hr. after completion of compaction, add additional cement as directed. Provide additional work and material at no additional cost to the Department.

4.5.1. **Ordinary Compaction**. Roll with approved compaction equipment, as directed. Correct irregularities, depressions, and weak spots immediately by scarifying the areas affected, adding or removing treated material as required, reshaping, and recompacting.

4.5.2. **Density Control**. Achieve at least 95% of the maximum density determined in accordance with Tex-120-E when compaction is complete. The Engineer will determine roadway density and moisture content in accordance with Tex-115-E. The Engineer may verify strength in accordance with Tex-120-E and adjust cement content to achieve the target strength for work going forward. Remove material that does not meet density requirements or rework by adding the target cement content, reshaping, recompacting, and refinishing at the Contractor’s expense.

The Engineer may accept the section if no more than 1 of the 5 most recent density tests is below the specified density and the failing test is no more than 3 pcf below the specified density.

4.6. **Finishing**. Immediately after completing compaction, clip, skin, or tight-blade the surface of the cement treated material with a maintainer or subgrade trimmer to a depth of approximately 1/4 in. Remove loosened material and dispose of it at an approved location. Roll the clipped surface immediately with a pneumatic-tire roller until a smooth surface is attained. Add small increments of water as needed during rolling. Shape and maintain the course and surface in conformity with the typical sections, lines and grades shown on the plans or as directed.

Finish grade of constructed subgrade to within 0.1 ft. in the cross-section and 0.1 ft. in 16 ft. measured longitudinally.

Correct grade deviations of constructed base greater than 1/4 in. in 16 ft. measured longitudinally or greater than 1/4 in. over the entire width of the cross-section in areas where surfacing is to be placed. Remove excess material, reshape, and roll with a pneumatic-tire roller. Correct as directed if material is more than 1/4 in. low. Do not surface patch.

4.7. **Microcracking**. When shown on the plans, maintain moisture content of the finished cement treated base for a period of 24 to 48 hr. During this time, but not sooner than 24 hr., roll the finished course with a vibratory roller to induce microcracking. The vibratory roller must be in accordance with Item 210, “Rolling,” with a static weight equal to or more than 12 tons and the vibratory drum must be not less than 20 in. wide. The roller must travel at a speed of 2 mph, vibrating at maximum amplitude, and make 2 to 4 passes with 100% coverage exclusive of the outside 1 ft. of the surface crown, unless otherwise directed by the Engineer. Additional passes may be required to achieve the desired crack pattern as directed. Notify the Engineer 24 hours before the microcracking begins.

4.8. **Curing**. Cure for at least 3 days by sprinkling in accordance with Item 204, “Sprinkling,” or by applying an asphalt material at the rate of 0.05 to 0.20 gal. per square yard, as shown on the plans or directed. When a section is microcracked, cure section for an additional 2 days after microcracking. Maintain the moisture content during curing at no lower than 2 percentage points below optimum. Continue curing until placing another course.

5. MEASUREMENT

5.1. **Cement**. Cement will be measured by the ton (dry weight). When cement is furnished in trucks, the weight of cement will be determined on certified scales, or the Contractor must provide a set of standard platform truck scales at a location approved by the Engineer. Scales must conform to the requirements of Item 520, “Weighing and Measuring Equipment.”

When cement is furnished in bags, indicate the manufacturer’s certified weight. Bags varying more than 5% from that weight may be rejected. The average weight of bags in any shipment, as determined by weighing 10 bags taken at random, must be at least the manufacturer’s certified weight.

Cement slurry will be measured by the ton (dry weight) of the cement used to prepare the slurry at the jobsite or from the minimum percent dry solids content of the slurry, multiplied by the weight of the slurry in tons delivered.

5.2. **Cement Treatment**. Cement treatment will be measured by the square yard of surface area. The dimensions for determining the surface areas are established by the widths shown on the plans and lengths measured at placement.

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid in accordance with Section 275.5.1., “Cement,” and Section 275.5.2., “Cement Treatment.”

Furnishing and delivering new base will be paid for in accordance with Section 247.6.2., “Flexible Base (Roadway Delivery).” Mixing, spreading, blading, shaping, compacting, and finishing new or existing base material will be paid for under Section 275.6.2., “Cement Treatment.” Removal and disposal of existing asphalt concrete pavement will be paid for in accordance with pertinent Items or Article 4.4., “Changes in the Work.”

Sprinkling and rolling, except proof-rolling, will not be paid for directly but will be subsidiary to this Item, unless otherwise shown on the plans. When proof-rolling is shown on the plans or directed by the Engineer, it will be paid for in accordance with Item 216, “Proof Rolling.”

Where subgrade is constructed under this Contract, correction of soft spots in the subgrade or existing base will be at the Contractor’s expense. Where subgrade is not constructed under this Contract, correction of soft spots in the subgrade or existing base will be in accordance with pertinent Items or Article 4.4., “Changes in the Work.”

Where subgrade to be treated under this Contract has sulfates greater than 7,000 ppm, work will be paid for in accordance with Article 4.4., “Changes in the Work.”

Asphalt used solely for curing will not be paid for directly but will be subsidiary to this Item. Asphalt placed for the purpose of curing and priming will be paid for under Item 310, “Prime Coat.”

6.1. **Cement**. Cement will be paid for at the unit price bid for “Cement.” This price is full compensation for materials, delivery, equipment, labor, tools, and incidentals.

6.2. **Cement Treatment**. Cement treatment will be paid for at the unit price bid for “Cement Treatment (Existing Material),” “Cement Treatment (New Base),” or “Cement Treatment (Mixing Existing Material and New Base),” for the depth specified. No payment will be made for thickness or width exceeding that shown on the plans. This price is full compensation for shaping existing material, loosening, mixing, pulverizing, spreading, applying cement, compacting, microcracking, finishing, curing, curing materials, blading, shaping and maintaining shape, replacing mixture, disposing of loosened materials, processing, hauling, preparing secondary subgrade, water, equipment, labor, tools, and incidentals.

Item 360
Concrete Pavement

1. DESCRIPTION

Construct hydraulic cement concrete pavement with or without curbs on the concrete pavement.

2. MATERIALS

2.1. **Hydraulic Cement Concrete**. Provide hydraulic cement concrete in accordance with Item 421, "Hydraulic Cement Concrete." Use compressive strength testing unless otherwise shown on the plans. Provide Class P concrete designed to meet a minimum average compressive strength of 3,200 psi or a minimum average flexural strength of 450 psi at 7 days or a minimum average compressive strength of 4,000 psi or a minimum average flexural strength of 570 psi at 28 days. Test in accordance with Tex-448-A or Tex-418-A.

Obtain written approval if the concrete mix design exceeds 520 lb. per cubic yard of cementitious material.

Use coarse aggregates for continuously reinforced concrete pavements to produce concrete with a coefficient of thermal expansion not more than 5.5×10^{-6} in./in./°F. Provide satisfactory Tex-428-A test data from an approved testing laboratory if the coarse aggregate coefficient of thermal expansion listed on the Department's *Concrete Rated Source Quality Catalog* is not equal to or less than 5.5×10^{-6} in./in./°F.

Provide Class HES concrete for very early opening of small pavement areas or leave-outs to traffic when shown on the plans or allowed. Design Class HES to meet the requirements of Class P and a minimum average compressive strength of 3,200 psi or a minimum average flexural strength of 450 psi in 24 hr., unless other early strength and time requirements are shown on the plans or allowed.

Use Class A or P concrete meeting the requirements of Item 421, "Hydrualic Cement Concrete," and this Item for curbs that are placed separately from the pavement.

2.2. **Reinforcing Steel**. Provide Grade 60 or above, deformed steel for bar reinforcement in accordance with Item 440, "Reinforcement for Concrete." Provide positioning and supporting devices (baskets and chairs) capable of securing and holding the reinforcing steel in proper position before and during paving. Provide corrosion protection when shown on the plans.

2.2.1. **Dowels**. Provide smooth, straight dowels of the size shown on the plans, free of burrs, and conforming to the requirements of Item 440, "Reinforcement for Concrete." Coat dowels with a thin film of grease, wax, silicone or other approved de-bonding material. Provide dowel caps on the lubricated end of each dowel bar used in an expansion joint. Provide dowel caps filled with a soft compressible material with enough range of movement to allow complete closure of the expansion joint.

2.2.2. **Tie Bars**. Provide straight deformed steel tie bars. Provide either multiple-piece tie bars or single-piece tie bars as shown on the plans. Furnish multiple piece tie bar assemblies from the list of approved multiple-piece tie bars that have been prequalified in accordance with DMS-4515, "Multiple Piece Tie Bars for Concrete Pavements," when used. Multiple-piece tie bars used on individual projects must be sampled in accordance with Tex-711-I, and tested in accordance with DMS-4515 "Multiple Piece Tie Bars for Concrete Pavements."

2.3. **Alternative Reinforcing Materials**. Provide reinforcement materials of the dimensions and with the physical properties specified when allowed or required by the plans. Provide manufacturer's certification of required material properties.

2.4. **Curing Materials**. Provide Type 2 membrane curing compound conforming to DMS-4650, "Hydraulic Cement Concrete Curing Materials and Evaporation Retardants." Provide SS-1 emulsified asphalt conforming to Item 300, "Asphalts, Oils, and Emulsions," for concrete pavement to be overlaid with asphalt concrete under this Contract unless otherwise shown on the plans or approved. Provide materials for other methods of curing conforming to the requirements of Item 422, "Concrete Superstructures." Provide insulating blankets for curing fast track concrete pavement with a minimum thermal resistance (R) rating of 0.5 hour-square foot F/BTU. Use insulating blankets that are free from tears and are in good condition.

2.5. **Epoxy**. Provide Type III, Class C epoxy in accordance with DMS-6100, "Epoxies and Adhesives," for installing all drilled-in reinforcing steel. Submit a work plan and request approval for the use of epoxy types other than Type III, Class C.

2.6. **Evaporation Retardant**. Provide evaporation retardant conforming to DMS-4650, "Hydraulic Cement Concrete Curing Materials and Evaporation Retardants."

2.7. **Joint Sealants and Fillers**. Provide Class 5 or Class 8 joint-sealant materials and fillers unless otherwise shown on the plans or approved and other sealant materials of the size, shape, and type shown on the plans in accordance with DMS-6310, "Joint Sealants and Fillers."

3. EQUIPMENT

Furnish and maintain all equipment in good working condition. Use measuring, mixing, and delivery equipment conforming to the requirements of Item 421, "Hydraulic Cement Concrete." Obtain approval for other equipment used.

3.1. **Placing, Consolidating, and Finishing Equipment**. Provide approved self-propelled paving equipment that uniformly distributes the concrete with minimal segregation and provides a smooth machine-finished consolidated concrete pavement conforming to plan line and grade. Provide an approved automatic grade control system on slip-forming equipment. Provide approved mechanically-operated finishing floats capable of producing a uniformly smooth pavement surface. Provide equipment capable of providing a fine, light water fog mist.

When string-less paving equipment is used, use Section 5.9.3, "Method C," and establish control points at maximum intervals of 500 ft. Use these control points as reference to perform the work.

Provide mechanically-operated vibratory equipment capable of adequately consolidating the concrete. Provide immersion vibrators on the paving equipment at sufficiently close intervals to provide uniform vibration and consolidation of the concrete over the entire width and depth of the pavement and in accordance with the manufacturer's recommendations. Provide immersion vibrator units that operate at a frequency in air of at least 8,000 cycles per minute. Provide enough hand-operated immersion vibrators for timely and proper consolidation of the concrete along forms, at all joints and in areas not covered by other vibratory equipment. Surface vibrators may be used to supplement equipment-mounted immersion vibrators. Provide tachometers to verify the proper operation of all vibrators.

For small or irregular areas or when approved, the paving equipment described in this Section is not required.

3.2. **Forming Equipment**.

3.2.1. **Pavement Forms**. Provide metal side forms of sufficient cross-section, strength, and rigidity to support the paving equipment and resist the impact and vibration of the operation without visible springing or settlement. Use forms that are free from detrimental kinks, bends, or warps that could affect ride quality or alignment. Provide flexible or curved metal or wood forms for curves of 100-ft. radius or less.

3.2.2. **Curb Forms**. Provide curb forms for separately placed curbs that are not slipformed that conform to the requirements of Item 529, "Concrete Curb, Gutter, and Combined Curb and Gutter."

3.3. **Reinforcing Steel Inserting Equipment**. Provide inserting equipment that accurately inserts and positions reinforcing steel in the plastic concrete parallel to the profile grade and horizontal alignment in accordance to plan details when approved.

3.4. **Texturing Equipment**.

3.4.1. **Carpet Drag**. Provide a carpet drag mounted on a work bridge or a manual moveable support system. Provide a single piece of carpet of sufficient transverse length to span the full width of the pavement being placed and adjustable so that a sufficient longitudinal length of carpet is in contact with the concrete being placed to produce the desired texture. Obtain approval to vary the length and width of the carpet to accommodate specific applications.

3.4.2. **Tining Equipment**. Provide a self-propelled metal tine device equipped with steel tines with cross-section approximately 1/32 in. thick × 1/12 in. wide. Provide tines for transverse tining equipment spaced at approximately 1 in., center-to-center, or provide tines for longitudinal tining equipment spaced at approximately 3/4 in., center-to-center. Manual methods that produce an equivalent texture may be used when it is impractical to use self-propelled equipment, such as for small areas, narrow width sections, and in emergencies due to equipment breakdown.

3.5. **Curing Equipment**. Provide a self-propelled machine for applying membrane curing compound using mechanically-pressurized spraying equipment with atomizing nozzles. Provide equipment and controls that maintain the required uniform rate of application over the entire paving area. Provide curing equipment that is independent of all other equipment when required to meet the requirements of Section 360.4.9., "Curing." Hand-operated pressurized spraying equipment with atomizing nozzles may only be used on small or irregular areas, narrow width sections, or in emergencies due to equipment breakdown.

3.6. **Sawing Equipment**. Provide power-driven concrete saws to saw the joints shown on the plans. Provide standby power-driven concrete saws during concrete sawing operations.

3.7. **Grinding Equipment**. Provide self-propelled powered grinding equipment that is specifically designed to smooth and texture concrete pavement using circular diamond blades when required. Provide equipment with automatic grade control capable of grinding at least a 3-ft. width longitudinally in each pass without damaging the concrete.

3.8. **Testing Equipment**. Provide testing equipment regardless of job-control testing responsibilities in accordance with Item 421, "Hydraulic Cement Concrete," unless otherwise shown on the plans or specified.

3.9. **Coring Equipment**. Provide coring equipment capable of extracting cores in accordance with the requirements of Tex-424-A when required.

3.10. **Miscellaneous Equipment**. Furnish both 10-ft. and 15-ft. steel or magnesium long-handled, standard straightedges. Furnish enough work bridges, long enough to span the pavement, for finishing and inspection operations.

4. CONSTRUCTION

Obtain approval for adjustments to plan grade-line to maintain thickness over minor subgrade or base high spots while maintaining clearances and drainage. Maintain subgrade or base in a smooth, clean, compacted condition in conformity with the required section and established grade until the pavement concrete is placed. Keep subgrade or base damp with water before placing pavement concrete.

Adequately light the active work areas for all nighttime operations. Provide and maintain tools and materials to perform testing.

4.1. **Paving and Quality Control Plan**. Submit a paving and quality control plan for approval before beginning pavement construction operations. Include details of all operations in the concrete paving process, including

methods to construct transverse joints, methods to consolidate concrete at joints, longitudinal construction joint layout, sequencing, curing, lighting, early opening, leave-outs, sawing, inspection, testing, construction methods, other details and description of all equipment. List certified personnel performing the testing. Submit revisions to the paving and quality control plan for approval.

4.2. **Job-Control Testing**. Perform all fresh and hardened concrete job-control testing at the specified frequency unless otherwise shown on the plans. Provide job-control testing personnel meeting the requirements of Item 421, "Hydraulic Cement Concrete." Provide and maintain testing equipment, including strength testing equipment at a location acceptable to the Engineer. Use of a commercial laboratory is acceptable. Maintain all testing equipment calibrated in accordance with pertinent test methods. Make strength-testing equipment available to the Engineer for verification testing.

Provide the Engineer the opportunity to witness all tests. The Engineer may require a retest if not given the opportunity to witness. Furnish a copy of all test results to the Engineer daily. Check the first few concrete loads for slump and temperature to verify concrete conformance and consistency on start-up production days. Sample and prepare strength-test specimens (2 specimens per test) on the first day of production and for each 3,000 sq. yd. or fraction thereof of concrete pavement thereafter. Prepare at least 1 set of strength-test specimens for each production day. Perform slump and temperature tests each time strength specimens are made. Monitor concrete temperature to ensure that concrete is consistently within the temperature requirements. The Engineer will direct random job-control sampling and testing. Immediately investigate and take corrective action as approved if any Contractor test result, including tests performed for verification purposes, does not meet specification requirements.

The Engineer will perform job-control testing when the testing by the Contractor is waived by the plans; however, this does not waive the Contractor's responsibility for providing materials and work in accordance with this Item.

4.2.1. **Job-Control Strength**. Use 7-day job-control concrete strength testing in accordance with Tex-448-A or Tex-418-A unless otherwise shown on the plans or permitted.

Use a compressive strength of 3,200 psi or a lower job-control strength value proven to meet a 28-day compressive strength of 4,000 psi as correlated in accordance with Tex-427-A for 7-day job-control by compressive strength. Use a flexural strength of 450 psi or a lower job-control strength value proven to meet a 28-day flexural strength of 570 psi as correlated in accordance with Tex-427-A for 7-day job-control by flexural strength.

Job control of concrete strength may be correlated to an age other than 7 days in accordance with Tex-427-A when approved. Job-control strength of Class HES concrete is based on the required strength and time.

Investigate the strength test procedures, the quality of materials, the concrete production operations, and other possible problem areas to determine the cause when a job-control concrete strength test value is more than 10% below the required job-control strength or when 3 consecutive job-control strength values fall below the required job-control strength. Take necessary action to correct the problem, including redesign of the concrete mix if needed. The Engineer may suspend concrete paving if the Contractor is unable to identify, document, and correct the cause of low-strength test values in a timely manner. The Engineer will evaluate the structural adequacy of the pavements if any job-control strength is more than 15% below the required job-control strength. Remove and replace pavements found to be structurally inadequate at no additional cost when directed.

4.2.2. **Split-Sample Verification Testing**. Perform split-sample verification testing with the Engineer on random samples taken and split by the Engineer at a rate of at least 1 for every 10 job-control samples. The Engineer will evaluate the results of split-sample verification testing. Immediately investigate and take corrective action as approved when results of split-sample verification testing differ more than the allowable differences shown in Table 1, or the average of 10 job-control strength results and the Engineer's split-sample strength result differ by more than 10%.

Table 1
Verification Testing Limits

Test Method	Allowable Differences
Temperature, Tex-422-A	2°F
Flexural strength, Tex-448-A	19%
Compressive strength, Tex-418-A	10%

4.3. **Reinforcing Steel and Joint Assemblies**. Accurately place and secure in position all reinforcing steel as shown on the plans. Place dowels at mid-depth of the pavement slab, parallel to the surface. Place dowels for transverse contraction joints parallel to the pavement edge. Tolerances for location and alignment of dowels will be shown on the plans. Stagger the lap locations so that no more than 1/3 of the longitudinal steel is spliced in any given 12-ft. width and 2-ft. length of the pavement. Use multiple-piece tie bars, drill and epoxy grout tie bars, or, if approved, mechanically-inserted single-piece tie bars at longitudinal construction joints. Verify that tie bars that are drilled and epoxied or mechanically inserted into concrete at longitudinal construction joints develop a pullout resistance equal to a minimum of 3/4 of the yield strength of the steel after 7 days. Test 15 bars using ASTM E488, except that alternate approved equipment may be used. All 15 tested bars must meet the required pullout strength. Perform corrective measures to provide equivalent pullout resistance if any of the test results do not meet the required minimum pullout strength. Repair damage from testing. Acceptable corrective measures include but are not limited to installation of additional or longer tie bars.

4.3.1. **Manual Placement**. Secure reinforcing bars at alternate intersections with wire ties or locking support chairs. Tie all splices with wire.

4.3.2. **Mechanical Placement**. Complete the work using manual placement methods described above if mechanical placement of reinforcement results in steel misalignment or improper location, poor concrete consolidation, or other inadequacies.

4.4. **Joints**. Install joints as shown on the plans. Joint sealants are not required on concrete pavement that is to be overlaid with asphaltic materials. Clean and seal joints in accordance with Item 438, “Cleaning and Sealing Joints.” Repair excessive spalling of the joint saw groove using an approved method before installing the sealant. Seal all joints before opening the pavement to all traffic. Install a rigid transverse bulkhead, for the reinforcing steel, and shaped accurately to the cross-section of the pavement when placing of concrete is stopped.

4.4.1. **Placing Reinforcement at Joints**. Complete and place the assembly of parts at pavement joints at the required location and elevation, with all parts rigidly secured in the required position, when shown on the plans.

4.4.2. **Transverse Construction Joints**.

4.4.2.1. **Continuously Reinforced Concrete Pavement (CRCP)**. Install additional longitudinal reinforcement through the bulkhead when shown on the plans. Protect the reinforcing steel immediately beyond the construction joint from damage, vibration, and impact.

4.4.2.2. **Concrete Pavement Contraction Design (CPCD)**. Install and rigidly secure a complete joint assembly and bulkhead in the planned transverse contraction joint location when the placing of concrete is intentionally stopped. Install a transverse construction joint either at a planned transverse contraction joint location or mid-slab between planned transverse contraction joints when the placing of concrete is unintentionally stopped. Install tie bars of the size and spacing used in the longitudinal joints for mid-slab construction joints.

4.4.2.3. **Curb Joints**. Provide joints in the curb of the same type and location as the adjacent pavement. Use expansion joint material of the same thickness, type, and quality required for the pavement and of the section shown for the curb. Extend expansion joints through the curb. Construct curb joints at all transverse pavement joints. Place reinforcing steel into the plastic concrete pavement for non-monolithic curbs as shown on the plans unless otherwise approved. Form or saw the weakened plane joint across the full width

of concrete pavement and through the monolithic curbs. Construct curb joints in accordance with Item 529, "Concrete Curb, Gutter, and Combined Curb and Gutter."

4.5. **Placing and Removing Forms**. Use clean and oiled forms. Secure forms on a base or firm subgrade that is accurately graded and that provides stable support without deflection and movement by form riding equipment. Pin every form at least at the middle and near each end. Tightly join and key form sections together to prevent relative displacement.

Set side forms far enough in advance of concrete placement to permit inspection. Check conformity of the grade, alignment, and stability of forms immediately before placing concrete, and make all necessary corrections. Use a straightedge or other approved method to test the top of forms to ensure that the ride quality requirements for the completed pavement will be met. Stop paving operations if forms settle or deflect more than 1/8 in. under finishing operations. Reset forms to line and grade, and refinish the concrete surface to correct grade.

Avoid damage to the edge of the pavement when removing forms. Repair damage resulting from form removal and honeycombed areas with a mortar mix within 24 hr. after form removal unless otherwise approved. Clean joint face and repair honeycombed or damaged areas within 24 hr. after a bulkhead for a transverse construction joint has been removed unless otherwise approved. Promptly apply membrane curing compound to the edge of the concrete pavement when forms are removed before 72 hr. after concrete placement.

Forms that are not the same depth as the pavement, but are within 2 in. of that depth are permitted if the subbase is trenched or the full width and length of the form base is supported with a firm material to produce the required pavement thickness. Promptly repair the form trench after use. Use flexible or curved wood or metal forms for curves of 100-ft. radius or less.

4.6. **Concrete Delivery**. Clean delivery equipment as necessary to prevent accumulation of old concrete before loading fresh concrete. Use agitated delivery equipment for concrete designed to have a slump of more than 5 in. Segregated concrete is subject to rejection.

Begin the discharge of concrete delivered in agitated delivery equipment conforming to the requirements of Item 421, "Hydraulic Cement Concrete." Place non-agitated concrete within 45 min. after batching. Reduce times as directed when hot weather or other conditions cause quick setting of the concrete.

4.7. **Concrete Placement**. Do not allow the pavement edge to deviate from the established paving line by more than 1/2 in. at any point. Place the concrete as near as possible to its final location, and minimize segregation and rehandling. Distribute concrete using shovels where hand spreading is necessary. Do not use rakes or vibrators to distribute concrete.

4.7.1. **Consolidation**. Consolidate all concrete by approved mechanical vibrators operated on the front of the paving equipment. Use immersion-type vibrators that simultaneously consolidate the full width of the placement when machine finishing. Keep vibrators from dislodging reinforcement. Use hand-operated vibrators to consolidate concrete along forms, at all joints and in areas not accessible to the machine-mounted vibrators. Do not operate machine-mounted vibrators while the paving equipment is stationary. Vibrator operations are subject to review.

4.7.2. **Curbs**. Conform to the requirements of Item 529, "Concrete Curb, Gutter, and Combined Curb and Gutter" where curbs are placed separately.

4.7.3. **Temperature Restrictions**. Place concrete that is between 40°F and 95°F when measured in accordance with Tex-422-A at the time of discharge, except that concrete may be used if it was already in transit when the temperature was found to exceed the allowable maximum. Take immediate corrective action or cease concrete production when the concrete temperature exceeds 95°F.

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 above 35°F and rising or

above 40°F. Protect the pavement with an approved insulating material capable of protecting the concrete for the specified curing period when temperatures warrant protection against freezing. Submit for approval proposed measures to protect the concrete from anticipated freezing weather for the first 72 hr. after placement. Repair or replace all concrete damaged by freezing.

4.8. **Spreading and Finishing**. Finish all concrete pavement with approved self-propelled equipment. Use power-driven spreaders, power-driven vibrators, power-driven strike-off, screed, or approved alternate equipment. Use the transverse finishing equipment to compact and strike-off the concrete to the required section and grade without surface voids. Use float equipment for final finishing. Use concrete with a consistency that allows completion of all finishing operations without addition of water to the surface. Use the minimal amount of water fog mist necessary to maintain a moist surface. Reduce fogging if float or straightedge operations result in excess slurry.

4.8.1. **Finished Surface**. Perform sufficient checks with long-handled 10-ft. and 15-ft. straightedges on the plastic concrete to ensure the final surface is within the tolerances specified in Surface Test A in Item 585, "Ride Quality for Pavement Surfaces." Check with the straightedge parallel to the centerline.

4.8.2. **Maintenance of Surface Moisture**. Prevent surface drying of the pavement before application of the curing system by means that may include water fogging, the use of wind screens, and the use of evaporation retardants. Apply evaporation retardant at the manufacturer's recommended rate. Reapply the evaporation retardant as needed to maintain the concrete surface in a moist condition until curing system is applied. Do not use evaporation retardant as a finishing aid. Failure to take acceptable precautions to prevent surface drying of the pavement will be cause for shutdown of pavement operations.

4.8.3. **Surface Texturing**. Complete final texturing before the concrete has attained its initial set. Drag the carpet longitudinally along the pavement surface with the carpet contact surface area adjusted to provide a satisfactory coarsely textured surface. Prevent the carpet from getting plugged with grout. Do not perform carpet dragging operations while there is excessive bleed water.

A metal-tine texture finish is required unless otherwise shown on the plans. Provide transverse tining unless otherwise shown on the plans. Immediately following the carpet drag, apply a single coat of evaporation retardant, if needed, at the rate recommended by the manufacturer. Provide the metal-tine finish immediately after the concrete surface has set enough for consistent tining. Operate the metal-tine device to obtain grooves approximately 3/16 in. deep, with a minimum depth of 1/8 in., and approximately 1/12 in. wide. Do not overlap a previously tined area. Use manual methods to achieve similar results on ramps, small or irregular areas, and narrow width sections of pavements. Repair damage to the edge of the slab and joints immediately after texturing. Do not tine pavement that will be overlaid or that is scheduled for blanket diamond grinding or shot blasting.

Target a carpet drag texture of 0.04 in., as measured by Tex-436-A, when carpet drag is the only surface texture required on the plans. Ensure adequate and consistent macro-texture is achieved by applying enough weight to the carpet and by keeping the carpet from getting plugged with grout. Correct any location with a texture less than 0.03 in. by diamond grinding or shot blasting. The Engineer will determine the test locations at points located transversely to the direction of traffic in the outside wheel path.

4.8.4. **Small, Irregular Area, or Narrow Width Placements**. Use hand equipment and procedures that produce a consolidated and finished pavement section to the line and grade where machine placements and finishing of concrete pavement are not practical.

4.8.5. **Emergency Procedures**. Use hand-operated equipment for applying texture, evaporation retardant, and cure in the event of equipment breakdown.

4.9. **Curing**. Keep the concrete pavement surface from drying as described in Section 360.4.8.2., "Maintenance of Surface Moisture," until the curing material has been applied. Maintain and promptly repair damage to curing materials on exposed surfaces of concrete pavement continuously for at least 3 curing days. A curing day is defined as a 24-hr. period when either the temperature taken in the shade away from artificial heat is above 50°F for at least 19 hr. or the surface temperature of the concrete is maintained above 40°F for 24 hr.

Curing begins when the concrete curing system has been applied. Stop concrete paving if curing compound is not being applied promptly and maintained adequately. Other methods of curing in accordance with Item 422, "Concrete Superstructures," may be used when specified or approved.

4.9.1. **Membrane Curing**. Spray the concrete surface uniformly with 2 coats of membrane curing compound at an individual application rate of no more than 180 sq. ft. per gallon. Apply the curing compound before allowing the concrete surface to dry.

Manage finishing and texturing operations to ensure placement of curing compound on a moist concrete surface, relatively free of bleed water, to prevent any plastic shrinkage cracking. Time the application of curing compound to prevent plastic shrinkage cracking.

Maintain curing compounds in a uniformly agitated condition, free of settlement before and during application. Do not thin or dilute the curing compound.

Apply additional compound at the same rate of coverage to correct damage where the coating shows discontinuities or other defects or if rain falls on the newly coated surface before the film has dried enough to resist damage. Ensure that the curing compound coats the sides of the tining grooves.

4.9.2. **Asphalt Curing**. Apply a uniform coating of asphalt curing at a rate of 90 to 180 sq. ft. per gallon when an asphaltic concrete overlay is required. Apply curing immediately after texturing and once the free moisture (sheen) has disappeared. Obtain approval to add water to the emulsion to improve spray distribution. Maintain the asphalt application rate when using diluted emulsions. Maintain the emulsion in a mixed condition during application.

4.9.3. **Curing Class HES Concrete**. Provide membrane curing in accordance with Section 360.4.9.1., "Membrane Curing," for all Class HES concrete pavement. Promptly follow by wet mat curing in accordance with Section 422.4.8., "Final Curing," until opening strength is achieved but not less than 24 hr.

4.9.4. **Curing Fast-Track Concrete Pavement**. Provide wet mat curing unless otherwise shown on the plans or as directed. Cure in accordance with Section 422.4.8., "Final Curing." Apply a Type 1-D or Type 2 membrane cure instead of wet mat curing if the air temperature is below 65°F and insulating blankets are used.

4.10. **Sawing Joints**. Saw joints to the depth shown on the plans as soon as sawing can be accomplished without damage to the pavement regardless of time of day or weather conditions. Some minor raveling of the saw-cut is acceptable. Use a chalk line, string line, sawing template, or other approved method to provide a true joint alignment. Provide enough saws to match the paving production rate to ensure sawing completion at the earliest possible time to avoid uncontrolled cracking. Reduce paving production if necessary to ensure timely sawing of joints. Promptly restore membrane cure damaged within the first 72 hr. of curing.

4.11. **Protection of Pavement and Opening to Traffic**. Testing for early opening is the responsibility of the Contractor regardless of job-control testing responsibilities unless otherwise shown on the plans or as directed. Testing result interpretation for opening to traffic is subject to approval.

4.11.1. **Protection of Pavement**. Erect and maintain barricades and other standard and approved devices that will exclude all vehicles and equipment from the newly placed pavement for the periods specified. Protect the pavement from damage due to crossings using approved methods before opening to traffic. Where a detour is not readily available or economically feasible, an occasional crossing of the roadway with overweight equipment may be permitted for relocating equipment only but not for hauling material. When an occasional crossing of overweight equipment is permitted, temporary matting or other approved methods may be required.

Maintain an adequate supply of sheeting or other material to cover and protect fresh concrete surface from weather damage. Apply as needed to protect the pavement surface from weather.

4.11.2. **Opening Pavement to All Traffic**. Pavement that is 7 days old may be opened to all traffic. Clean pavement, place stable material against the pavement edges, seal joints, and perform all other traffic safety related work before opening to traffic.

4.11.3. **Opening Pavement to Construction Equipment**. Unless otherwise shown on the plans, concrete pavement may be opened early to concrete paving equipment and related delivery equipment after the concrete is at least 48 hr. old and opening strength has been demonstrated in accordance with Section 360.4.11.4., "Early Opening to All Traffic," before curing is complete. Keep delivery equipment at least 2 ft. from the edge of the concrete pavement. Keep tracks of the paving equipment at least 1 ft. from the pavement edge. Protect textured surfaces from the paving equipment. Restore damaged membrane curing as soon as possible. Repair pavement damaged by paving or delivery equipment before opening to all traffic.

4.11.4. **Early Opening to All Traffic**. Concrete pavement may be opened after curing is complete and the concrete has attained a flexural strength of 450 psi or a compressive strength of 3,200 psi, except that pavement using Class HES concrete may be opened after 24 hr. if the specified strength is achieved.

4.11.4.1. **Strength Testing**. Test concrete specimens cured under the same conditions as the portion of the pavement involved.

4.11.4.2. **Maturity Method**. Use the maturity method, Tex-426-A, to estimate concrete strength for early opening pavement to traffic unless otherwise shown on the plans. Install at least 2 maturity sensors for each day's placement in areas where the maturity method will be used for early opening. Maturity sensors, when used, will be installed near the day's final placement for areas being evaluated for early opening. Use test specimens to verify the strength–maturity relationship in accordance with Tex-426-A, starting with the first day's placement corresponding to the early opening pavement section.

Verify the strength–maturity relationship at least every 10 days of production after the first day. Establish a new strength–maturity relationship when the strength specimens deviate more than 10% from the maturity-estimated strengths. Suspend use of the maturity method for opening pavements to traffic when the strength–maturity relationship deviates by more than 10% until a new strength–maturity relationship is established.

The Engineer will determine the frequency of verification when the maturity method is used intermittently or for only specific areas.

4.11.5. **Fast Track Concrete Pavement**. Open the pavement after the concrete has been cured for at least 8 hr. and attained a minimum compressive strength of 1,800 psi or a minimum flexural strength of 255 psi when tested in accordance with Section 360.4.11.4.1., "Strength Testing," or Section 360.4.11.4.2., "Maturity Method," unless otherwise directed. Cover the pavement with insulating blankets when the air temperature is below 65°F until the pavement is opened to traffic.

4.11.6. **Emergency Opening to Traffic**. Open the pavement to traffic under emergency conditions, when the pavement is at least 72 hr. old when directed in writing. Remove all obstructing materials, place stable material against the pavement edges, and perform other work involved in providing for the safety of traffic as required for emergency opening.

4.12. **Pavement Thickness**. The Engineer will check the thickness in accordance with Tex-423-A unless other methods are shown on the plans. The Engineer will perform 1 thickness test consisting of 1 reading at approximately the center of the paving equipment every 500 ft. or fraction thereof. Core where directed, in accordance with Tex-424-A, to verify deficiencies of more than 0.2 in. from plan thickness and to determine the limits of deficiencies of more than 0.75 in. from plan thickness. Fill core holes using an approved concrete mixture and method.

4.12.1. **Thickness Deficiencies Greater than 0.2 in.** Take one 4-in. diameter core at that location to verify the measurement when any depth test measured in accordance with Tex-423-A is deficient by more than 0.2 in. from the plan thickness.

Take 2 additional cores from the unit (as defined in Section 360.4.12.3., "Pavement Units for Payment Adjustment" at intervals of at least 150 ft. and at selected locations if the core is deficient by more than 0.2 in., but not by more than 0.75 in. from the plan thickness, and determine the thickness of the unit for payment purposes by averaging the length of the 3 cores. In calculations of the average thickness of this unit of pavement, measurements in excess of the specified thickness by more than 0.2 in. will be considered as the specified thickness plus 0.2 in.

4.12.2. **Thickness Deficiencies Greater than 0.75 in.** Take additional cores at 10-ft. intervals in each direction parallel to the centerline to determine the boundary of the deficient area if a core is deficient by more than 0.75 in. The Engineer will evaluate any area of pavement found deficient in thickness by more than 0.75 in., but not more than 1 in. Remove and replace the deficient areas without additional compensation or retain deficient areas without compensation, as directed. Remove and replace any area of pavement found deficient in thickness by more than 1 in. without additional compensation.

4.12.3. **Pavement Units for Payment Adjustment**. Limits for applying a payment adjustment for deficient pavement thickness from 0.20 in. to not more than 0.75 in. are 500 ft. of pavement in each lane. Lane width will be as shown on typical sections and pavement design standards.

For greater than 0.75 in. deficient thickness, the limits for applying zero payment or requiring removal will be defined by coring or equivalent nondestructive means as determined by the Engineer. The remaining portion of the unit determined to be less than 0.75 in. deficient will be subject to the payment adjustment based on the average core thickness at each end of the 10-ft. interval investigation as determined by the Engineer.

Shoulders will be measured for thickness unless otherwise shown on the plans. Shoulders 6 ft. wide or wider will be considered as lanes. Shoulders less than 6 ft. wide will be considered part of the adjacent lane.

Limits for applying payment adjustment for deficient pavement thickness for ramps, widenings, acceleration and deceleration lanes, and other miscellaneous areas are 500 ft. in length. Areas less than 500 ft. in length will be individually evaluated for payment adjustment based on the plan area.

4.13. **Ride Quality**. Measure ride quality in accordance with Item 585, "Ride Quality for Pavement Surfaces," unless otherwise shown on the plans.

5. MEASUREMENT

This Item will be measured as follows:

5.1. **Concrete Pavement**. Concrete pavement will be measured by the square yard of surface area in place. The surface area includes the portion of the pavement slab extending beneath the curb.

5.2. **Curb**. Curb on concrete pavement will be measured by the foot in place.

6. PAYMENT

These prices are full compensation for materials, equipment, labor, tools, and incidentals.

6.1. **Concrete Pavement**. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the adjusted unit price bid for "Concrete Pavement" of the type and depth specified as adjusted in accordance with Section 360.6.2., "Deficient Thickness Adjustment."

6.2. **Deficient Thickness Adjustment**. Where the average thickness of pavement is deficient in thickness by more than 0.2 in. but not more than 0.75 in., payment will be made using the adjustment factor as specified in Table 2 applied to the bid price for the deficient area for each unit as defined under Section 360.4.12.3., "Pavement Units for Payment Adjustment."

Table 2
Deficient Thickness Price Adjustment Factor

Deficiency in Thickness Determined by Cores (in.)	Proportional Part of Contract Price Allowed (Adjustment Factor)
Not deficient	1.00
Over 0.00 through 0.20	1.00
Over 0.20 through 0.30	0.80
Over 0.30 through 0.40	0.72
Over 0.40 through 0.50	0.68
Over 0.50 through 0.75	0.57

6.3. **Curb**. Work performed and furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Curb" of the type specified.

Item 361
Repair of Concrete Pavement

1. DESCRIPTION

Repair concrete pavement to half-depth or full-depth in accordance with the details shown on the plans and the requirements of this Item.

2. MATERIALS

Furnish materials in accordance with the following:

- Item 360, "Concrete Pavement,"
- Item 421, "Hydraulic Cement Concrete,"
- Item 440, "Reinforcement for Concrete,"
- DMS-6100, "Epoxies and Adhesives," and
- DMS-4655, "Concrete Repair Materials."

2.1. **Half-Depth Repair**. Obtain approval for the repair material mix design. The selection of repair material should be based on the time for opening to traffic and temperature range during the repair.

Provide Class HES concrete in accordance with Item 421, "Hydraulic Cement Concrete," and designed to attain a minimum average flexural strength of 255 psi or a minimum average compressive strength of 1,800 psi within the timeframe designated for opening to traffic if it is less than 72 hr. after concrete placement. Otherwise, provide Class S conforming to Item 421, "Hydraulic Cement Concrete" or Class P concrete conforming to Item 360, "Concrete Pavement."

Provide material meeting the requirements of DMS-4655, "Concrete Repair Materials," Type A when Class HES concrete does not meet the strength requirement within the designated timeframe.

2.2. **Full-Depth Repair**. Obtain approval for the repair material mix design. The selection of repair material should be based on the time for opening to traffic and temperature range during the repair.

2.2.1. **Hydraulic Cement Concrete for Pavement**. Provide Class HES concrete designed to attain a minimum average flexural strength of 255 psi or a minimum average compressive strength of 1,800 psi within the designated timeframe if the timeframe designated for opening to traffic is less than 72 hr. after concrete placement. Otherwise, provide Class P concrete conforming to Item 360, "Concrete Pavement."

2.2.2. **Base Material**. Furnish cold-mix asphaltic materials for replacement base material when shown on the plans. The Engineer may waive quality control (QC) tests for base material.

2.2.3. **Asphalt Concrete**. Furnish asphalt concrete material for overlay and asphalt shoulder repair as shown on the plans. The Engineer may waive QC tests for this material.

3. EQUIPMENT

Provide tools and equipment necessary for proper execution of the work that meet the pertinent requirements of the following:

- Item 360, "Concrete Pavement"
- **Concrete Demolition Equipment**. Provide chipping hammers or hydro-demolition equipment for the bulk removal of concrete.

- **Concrete Lift-Out Equipment**. Provide steel chains, lift pins, and a crane or front-end loader capable of lifting the concrete and loading it onto a flatbed or dump truck.
- **Drill**. Use a maximum 40-lb. drill with tungsten carbide bits.
- **Air Compressor**. Provide compressor equipped with filters designed to remove oil from the air and capable of delivering air to remove dust and debris.

4. CONSTRUCTION

Submit for approval all materials and methods of application at least 2 weeks before beginning any repair work. Repair locations will be as indicated on the plans or as directed. Repair areas may be adjusted after removing distressed concrete. Switch the half-depth repair to the full-repair if exposed existing longitudinal bars are deficient, as approved. Compensation will be made for unexpected volumes of repair areas or changes in scope of work.

4.1. **Half-Depth Repair**. Repair locations will be as indicated on the plans or as directed. Repair boundaries should be square or rectangular with a minimum length and width of 12 in.

Saw-cut repair boundaries to a minimum depth of 1-1/2 in. Do not saw-cut longitudinal or transverse steel. If the longitudinal steel is cut, a full-depth repair may be required as directed without additional compensation.

Remove concrete from the repair area as designated. Start at the center of the repair area. Ensure all loose concrete materials are removed and only sound concrete is left in place. Increase the repair area and perform a full-depth repair as directed if longitudinal steel bars were damaged by the removal operations. No additional compensation will be made.

Clean the area to be repaired by approved methods. Remove all loose particles, dirt, deteriorated concrete, or other substances that would impair the bond of the repair material.

Mix, place, and cure in accordance with the manufacturer's recommendation when material in DMS-4655, "Concrete Repair Materials," is used. Mix, place, and cure concrete in accordance with Item 360, "Concrete Pavement." when Class S, Class P, or Class HES is used. Test Class S, Class P, and Class HES concrete to the requirements of Section 360.4.2., "Job-Control Testing."

Match the grade and alignment of existing concrete pavement unless otherwise shown on the plans. Concrete pavement may be opened to traffic when specified strength is achieved.

4.2. **Full-Depth Repair**. Repair areas identified by the Engineer. Make repair areas rectangular, at least 6 ft. long and at least 1/2 a full lane in width unless otherwise shown on the plans. Accept ownership of all removed material, and dispose of it in accordance with federal, state, and local regulations unless otherwise shown on the plans. Saw-cut and remove existing asphalt concrete overlay at least 2 ft. longer than the repair patch in each longitudinal direction when there is existing asphalt concrete overlay over the repair area.

Saw-cut the full depth through the concrete around the perimeter of the repair area before removal. Schedule work so that concrete placement follows full-depth saw-cutting by no more than 7 days unless otherwise shown on the plans or approved.

Remove the slab by lifting the slab with a minimum disturbance to the base materials and surrounding concrete. Do not spall or fracture concrete adjacent to the repair area. Saw-cut and remove additional concrete as directed, after slab removal, if distresses are found in the surrounding concrete pavement. Repair damages to concrete pavement caused by the Contractor's operation without additional compensation. Perform repairs as directed.

Remove loose or damaged base material completely, leaving no loose base material.

Recompact base materials to the satisfaction of the Engineer. Level the base layer with cold-mix asphalt to the original bottom line and grade of the concrete slab before repair concrete is placed when shown on the plans. Place concrete directly onto the compacted base layer unless otherwise directed.

Use tie bars to restore the continuity of the concrete pavement. Demonstrate, through simulated job conditions, that the bond strength of the epoxy-grouted tie bars meets a pullout strength of at least 3/4 of the yield strength of the tie bar when tested in accordance with ASTM E488 within the epoxy manufacturer's recommended curing time. Increase embedment depth and retest when necessary to meet testing requirements. Perform tie bar testing before starting repair work.

Place tie bars as shown on the plans. Drill holes into the existing concrete at least 10 in. deep unless otherwise directed. Use a drill bit with a diameter that is 1/8 in. greater than that of tie bars. Clean the holes with a wire brush and compressed air to remove all the dust and moisture. Follow the epoxy manufacturer's instructions to apply the epoxy. Insert the tip of the epoxy cartridge or the tip of the machine applicator to the end of the tie bar hole, and inject Type III, Class C epoxy to fill the entire hole. Insert tie bars.

Place new deformed reinforcing steel bars of the same size and spacing as shown on the plans for Continuously Reinforced Concrete Pavement (CRCP) repairs. Lap all longitudinal reinforcing steel at least 25 in. Provide and place approved supports to firmly hold the new reinforcing steel in place when needed.

Place dowel bars as shown on the plans for Concrete Pavement Contraction Design (CPCD) repairs. Provide and place approved supports to firmly hold the dowel bars in place.

Mix, place, cure, and test concrete to the requirements of Item 360, "Concrete Pavement," and Item 421, "Hydraulic Cement Concrete." Broom-finish the concrete surface unless otherwise shown on the plans.

Perform a timely saw-cut over the dowel bars and restore the transverse contraction joint for CPCD. Restore the existing longitudinal joints to the requirements of Section 360.4.4., "Joints."

Match the grade and alignment of existing concrete pavement. Replace any asphalt overlay and shoulder material removed with new asphalt concrete material after concrete strength requirements have been met.

Remove repair area debris from the right of way each day. Concrete pavement may be opened to traffic when specified strength is achieved.

5. MEASUREMENT

This Item will be measured by the square yard in place of the completed concrete surface area repaired.

6. PAYMENT

The work performed and the materials furnished in accordance with this Item and measured as specified under "Measurement" will be paid for at the unit price bids for "Repair of Concrete Pavement (Half-Depth)" and "Repair of Concrete Pavement (Full-Depth)." This price is full compensation for removal, stockpiling, and disposal of waste material and for equipment, materials, labor, tools, and incidentals. Asphalt concrete, base material, and curbing will not be paid for directly but will be considered subsidiary to this Item.

Item 422
Concrete Superstructures

1. DESCRIPTION

Construct reinforced concrete bridge slabs, decks, flat slabs, slab and girder units (pan formed), approach slabs, or other bridge superstructure elements as indicated.

2. MATERIALS

2.1. **Concrete**. Provide concrete conforming to Item 421, "Hydraulic Cement Concrete." Provide Class S or S (HPC) concrete for all cast-in-place concrete unless otherwise shown on the plans. Provide the class of concrete for precast components indicated on the plans or in pertinent governing Items.

2.2. **Reinforcing Steel**. Provide reinforcing steel in accordance with Item 440, "Reinforcement for Concrete."

2.3. **Structural Grout**. Provide grout in accordance with DMS-4675, "Cementitious Grouts and Mortars for Miscellaneous Applications" or as indicated on the plans.

2.4. **Expansion Joint Material**. Provide materials in accordance with DMS-6310, "Joint Sealants and Fillers."

- Provide preformed bituminous fiber expansion joint material unless indicated otherwise.
- 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.

2.5. **Foam Bedding Strips for Prestressed Concrete Panels**. Use extruded polystyrene conforming to ASTM C578, Type VI (40 psi compressive strength) or as specified.

Provide a manufacturer's certification or data sheet stating the foam meets these requirements. Use an adhesive or bonding agent compatible with polystyrene as recommended by the polystyrene manufacturer.

2.6. **Evaporation Retardants**. Provide evaporation retardants in accordance with DMS-4650, "Hydraulic Cement Concrete Curing Materials and Evaporation Retardants."

2.7. **Curing Materials**. Provide membrane curing compounds in accordance with 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 one side of the mat.

Provide polyethylene sheeting that is at least 4 mils thick and free from visible defects. Provide opaque white sheeting when the ambient temperature during curing exceeds 90°F.

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

Provide burlap material which complies with AASHTO M 182, Class 3 (10 oz. per square yard) with the following additions:

- Manila hemp may also be used to make burlap.
- Do not use burlap fabricated from bags.
- Do not use burlap containing any water soluble ingredient which will retard the setting time of concrete.

Provide used burlap complying with the requirements stated above, and that only has been used previously for curing concrete. "Like new" cleanliness is not expected, but contamination with any substance foreign to the concrete curing process, such as grease or oil, will be cause for rejection.

2.8. **Epoxy**. Provide epoxy materials that conform to DMS-6100, "Epoxies and Adhesives," unless otherwise specified.

3. EQUIPMENT

3.1. **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.

3.2. **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 that are watertight to control the fall of concrete and of large enough diameter to allow the placement of the concrete but less than 14 in. in diameter.

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

3.3. **Vibrators**. Use immersion-type vibrators for consolidation of concrete. Provide at least 1 standby vibrator for emergency use. Furnish vibrator head covered by a rubberized or elastomeric cover when used near epoxy coated reinforcing steel.

3.4. **Screeds and Work Bridges for Bridge Slabs**. Use a self-propelled transverse screed or a mechanical longitudinal screed for bridge slabs. 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.

Use sufficient work bridges for finishing operations for bridge slabs. 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 enough carpet is in contact longitudinally with the concrete being placed to provide the desired surface finish. Use artificial grass-type carpeting with a molded polyethylene pile face with a blade length between 5/8 and 1 in. and minimum weight of 70 oz. per square yard. Ensure the carpet has a strong, durable backing not subject to rot and 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.

3.5. **Temperature Recording Equipment**. Use strip chart temperature recording devices, recording maturity meters in accordance with Tex-426-A, or other approved devices that are accurate within ±2°F within the range of 32°F to 212°F.

3.6. **Artificial Heating Equipment**. Use artificial heating equipment as necessary for maintaining the concrete temperatures as specified in Section 422.4.6.11., "Placing Concrete in Cold Weather."

3.7. **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, nominally 1/8 in. wide, and spaced at 1 in. Use sawing equipment capable of cutting grooves in hardened concrete within 18 in. of the barrier rail or curb.

3.8. **Spraying Equipment**. Use mechanically powered pressure sprayers 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. Use hand-pressurized spray equipment equipped with 2 or 3 fan-spray nozzles if approved. Ensure the spray from each nozzle overlaps the spray from adjacent nozzles by approximately 50%.

3.9. **Concrete Testing Equipment**. Provide testing equipment for the Engineer's use in accordance with Section 421.3.3., "Testing Equipment."

4. CONSTRUCTION

Obtain approval for proposed construction methods before starting work. 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. Attend the pre-construction (pre-pour) meetings for bridge slabs conducted by the Engineer. Provide and obtain approval for proposed finishing methods, interim curing methods, and final curing methods.

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 8 of Section 421.4.1., "Classification of Concrete Mix Designs,") to determine the in-situ strength to address the schedule restrictions listed below. The Engineer may require the Contractor to perform this testing for concrete placed in cold weather. Make enough test specimens for Contractor-performed testing to ensure strength requirements are met for the operations listed below. 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 421.4.8., "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 Article 421.5., "Acceptance of Concrete," will be used for schedule restriction determinations. The Engineer may require additional time for strength gain to account for field curing conditions such as cold weather.

4.1. **Schedule Restrictions and Inspection Hold-Points**.

4.1.1. **Placement of Superstructure Members**. Place or cast superstructure members after the substructure concrete has attained a compressive strength of 3,000 psi.

4.1.2. **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.

4.1.3. **Staged Placement of Bridge Slabs on Continuous Steel Units**. Ensure the previously placed concrete attains a compressive strength of 3,000 psi when staged placement of a slab is required or used before

placing the next stage placement. Multiple stages may be placed in a single day if approved by the Engineer of Record.

4.1.4. **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.

4.1.5. **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 421.4.1., "Classification of Concrete Mix Designs," unless otherwise approved.

4.1.6. **Carting of Concrete** Cart, wheel, or pump concrete over completed slabs after the completed concrete has attained a compressive strength of 3,000 psi. Maintain curing during these operations.

4.1.7. **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. Ensure the slab concrete has attained its design strength specified in Section 421.4.1., "Classification of Concrete Mix Designs," before placing railing concrete if slipforming methods are used for railing concrete.

4.1.8. **Opening to Construction Traffic**. Bridges may be opened to all construction traffic when the design strength specified in Section 421.4.1., "Classification of Concrete Mix Designs," has been attained if curing is maintained. Avoid crossing bridges at high speeds until railing concrete, if present, has attained a compressive strength of 3,000 psi.

4.1.9. **Opening to Full Traffic**. Bridges may be opened to the traveling public when the design strength specified in Section 421.4.1., "Classification of Concrete Mix Designs," has been attained for all structural elements including railing subject to impact from traffic and when curing has been completed for all slabs. Obtain approval before opening bridges to the traveling public.

4.1.10. **Inspection Hold-Points**. Notify Engineer of progress of work and when work is complete before beginning next stage of work.

- Beam erection and bracing
- Formwork, including setting of precast panels
- Placing reinforcing steel
- Screed dry run and pre-pour clear cover checks
- Attend pre-pour meeting conducted by the Engineer
- Post-curing crack inspection

4.2. **Forms**. Submit forming plans for decks or slabs on beams or girders, overhangs, cast-in-place spans, and bracing systems for girders when the overhang exceeds 3 ft. 6 in. Submit similar plans for other units of the superstructure as directed. Show all essential details of proposed forms 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.

Design job-fabricated formwork assuming a weight of 150 pcf for concrete, and include a minimum 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.

Use conventional forms, permanent metal deck forms, or prestressed concrete panels for slabs on beams or girders unless indicated otherwise. Use permanent metal deck forms or conventional forms for thickened slabs, diaphragms, or other regions as shown on the plans where prestressed concrete panels are not used. Provide prestressed concrete panels as shown on the plans and in accordance with Item 424, "Precast Concrete Structural Members (Fabrication)." Provide copies of the precast panel layout drawings from the panel fabricator.

Use only material that is inert, non-biodegradable, and nonabsorptive for forms to be left in place.

Overhang 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.

Use beam bracing as indicated on the plans when overhang brackets are used on prestressed concrete beam spans with slab overhangs not exceeding 3 ft. 6 in. Provide and design additional support or bracing for the outside beams regardless of the type of beam used for spans with overhangs exceeding this amount.

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.”

When setting forms of any type take into account:

- deflections due to cast-in-place slab concrete and railing shown in the dead load deflection diagram,
- 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.

Securely stake forms to line and grade and maintain in position for bridge approach slabs. 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 placing concrete.

4.2.1. **Precast Panels**. Profile each beam to determine the actual camber or sag of the beams before placing panels. Adjust the profile grade line, panel elevation, and bearing seat elevations as needed to obtain the required cover over the slab reinforcement and slab thickness while maintaining ride quality. Make adjustments over suitable increments when a profile grade line adjustment is necessary, depending on span lengths, so the revised grade line will produce a uniform profile and good riding qualities. Obtain approval for the grade adjustments before placement. Consider actual beam camber in adjacent spans or slab placements when adjusting the grade line. Inspect each panel before being placed for cracks and other damage. Refer to Section 424.4.3.1., “Defects and Breakage,” for rejection criteria due to cracking and other damage.

4.2.2. **Permanent Metal Decking**. Submit signed and sealed design calculations in addition to the required formwork drawings. Design and install formwork in accordance with the plans and formwork drawings. The plans will govern in cases where the plans and the formwork drawings conflict.

4.2.3. **Conventional Forms**. Provide properly seasoned good-quality lumber 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.

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 any defect that will produce inferior work; remove such lumber from the work.

Use plywood at least 3/4 in. thick. 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.

Place forms with the form panels symmetrically (long dimensions set in the same direction) for surfaces exposed to view and receiving only an ordinary surface finish as defined in Section 420.4.13., "Ordinary Surface Finish." Make horizontal joints continuous.

Make molding for chamfer strips or other uses of materials of a grade that will not split when nailed and can be maintained to a true line without warping. Dress wood molding on all faces. Fill forms at all sharp corners and edges with triangular chamfer strips measuring 3/4 in. on the sides unless otherwise shown on the plans.

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

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

4.5. **Extending Existing Slabs**. Verify pertinent dimensions and elevations of the existing structure before ordering any required materials.

4.5.1. **Removal**. Remove portions of the existing structure to the lines and dimensions shown on the plans or as directed. Dispose of these materials as shown on the plans or as directed. Remove any metal railing without damaging it, and stack it neatly on the right of way at locations that do not interfere with traffic or construction or at locations shown on the plans. All removed metal railing remains the property of the Department unless otherwise shown on the plans. Repair any portion of the remaining structure damaged as a result of the construction. Do not use explosives to remove portions of the existing structure unless approved in writing. Do not use a demolition ball, other swinging weight, or impact equipment unless shown on the plans. Use pneumatic or hydraulic tools for final removal of concrete at the "break" line. Use removal equipment, as approved that will not damage the remaining concrete.

4.5.2. **Reuse of Removed Portions of Structure**. Detach and remove all portions of the old structure that are to be incorporated into the extended structure to the lines and details as specified on the plans or as directed. Move the unit to be reused to the new location specified using approved methods. Place the reinforcement and extension concrete according to the plan details.

4.5.3. **Breaking Back Bridge Slabs**. Saw the top surface of the slab for bridge slabs and direct traffic slabs of box culverts along the "break" line to a depth of 1/2 in. before breaking back. Do not cut the reinforcement at the "break" line. Sever the concrete at the "break" line. Do not damage the remaining reinforcement within 1 lap length of the "break" line during removal of the designated portion of the existing structure.

4.5.4. **Splicing Reinforcing Steel**. Splice new reinforcing bars to exposed bars in the existing structure using lap splices in accordance with Item 440, "Reinforcement for Concrete," unless otherwise shown on the plans. The new reinforcing steel does not need to be tied to the existing steel where spacing or elevation does not match that of the existing steel provided the lap length is attained. Weld in accordance with Item 448, "Structural Field Welding," when welded splices are permitted. Install any required dowels in accordance with Section 422.4.6.10., "Installation of Dowels and Anchor Bolts."

4.5.5. **Concrete Preparation**. Roughen and clean concrete surfaces that are in contact with new construction before the placing of forms. Prepare these construction joint surfaces in accordance with Section 422.4.6.7., "Construction Joints."

4.6. **Placing Concrete**. Do not place concrete unless approval is obtained for the hold-point inspections as outlined in Section 422.4.1.10., "Inspection Hold-Points," and the pre-pour meeting has been conducted. Give the Engineer sufficient advance notice before placing concrete in any unit of the structure to permit the final inspection of forms, reinforcing steel placement, and other preparations. Obtain approval for proposed

curing methods based on forecast weather conditions for the expected duration of the pour and use the evaporation rate nomograph as mentioned below to determine the required curing options.

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. Place concrete in early morning or at night or adjust the placement schedule for more favorable weather if conditions of wind, humidity, and temperature are such that concrete cannot be placed without the potential for plastic shrinkage cracking. Consult the evaporation rate nomograph in the Portland Cement Association's *Design and Control of Concrete Mixtures* or the evaporation rate spreadsheet available on the Department's website for shrinkage cracking potential. Adequately illuminate the entire placement site when mixing, placing, and finishing concrete in non-daylight hours as approved.

Furnish adequate shelter to protect the concrete against damage from rainfall or from freezing temperatures as outlined in this Item if changes in weather conditions require protective measures after work starts. 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.

4.6.1. **Placing Temperature**. Place superstructure concrete only when its temperature at the time of placement is between 50°F and 85°F. Increase the minimum placement temperature to 60°F if slag cement is used in the concrete.

4.6.2. **Transporting Time**. Begin the discharge of concrete delivered in truck mixers within the times listed in Table 14 of Item 421, "Hydraulic Cement Concrete."

4.6.3. **Workability of Concrete**. Place concrete with a slump as specified in Section 421.4.2.5., "Slump." Placing concrete with slump exceeding maximum specified may result in bridge deck cracking and be subject to Section 422.4.10., "Defective Work." Water may be added to the concrete before discharging any concrete from the truck to adjust for low slump provided the maximum mix design water-cement ratio is not exceeded. Mix concrete after introduction of any additional water or chemical admixtures in accordance with Section 421.4.6., "Mixing and Delivering Concrete." Do not add water or chemical admixtures after any concrete has been discharged.

4.6.4. **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 the concrete ingredients will not be separated. Terminate such equipment in vertical downspouts, when necessary, to prevent segregation. 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.

4.6.5. **Preparation of Surfaces**. Thoroughly wet all forms, prestressed concrete panels, T-beams, slab beams, and concrete box beams on which concrete is to be placed before placing concrete on them. Remove free water from the surface or beam lines before placing concrete. Provide surfaces that are in a moist, saturated surface-dry condition when concrete is placed on them.

Ensure the subgrade or foundation is moist before placing concrete for bridge approach slabs.

4.6.6. **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. Loosen these forms as soon as possible after final concrete set to permit free movement of the span without requiring full form removal and avoid expansion or contraction damage to the adjacent concrete.

Provide preformed fiber joint material or a high density foam in the vertical joints of the roadway slab, curb, median, or sidewalk when the plans show a Type A joint, and fill the top 1 in. with the specified joint sealing material unless noted otherwise. Install the sealer in accordance with Item 438, “Cleaning and Sealing Joints,” 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.

4.6.7. **Construction Joints**. A construction joint is formed by placing plastic concrete in direct contact with concrete that has attained its initial set. Monolithic placement means 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.

Make construction joints square and normal to the forms unless otherwise required. Use bulkheads in the forms for all vertical joints.

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. Ensure the surface of the existing concrete is in a saturated surface-dry (SSD) condition just before placing subsequent concrete. Prewet the existing concrete by ponding water on the surface for 24 hr. before placing subsequent concrete. Use high-pressure water blasting to achieve SSD conditions 15 to 30 min. before placing the concrete if ponding is not possible. An SSD condition is achieved when the surface remains damp when exposed to sunlight for 15 min.

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

Bonding agents are not required unless indicated otherwise. Coat the joint surface with bonding mortar, grout, epoxy, or other material as indicated on the plans or other Items if a bonding agent is required. 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 SSD, and place the concrete before the bonding mortar or grout dries. Place other bonding agents in accordance with the manufacturer’s recommendations.

4.6.8. **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. 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 one point and run or work the concrete along the forms.

Avoid cold joints in a monolithic placement. Sequence successive layers or adjacent portions of concrete so they can be vibrated into a homogeneous mass with the previously placed concrete before it sets.

4.6.9. **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 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. Concentrate vibration efforts along the beams lines when precast concrete panels are used for deck construction.

4.6.10. **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. Use only epoxy when installing horizontal dowels into the edges of slabs. Follow the manufacturer's recommended installation procedures for pre-packaged grout or epoxy anchor systems. Test anchors if required on the plans or by other Items.

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. Make the hole diameter 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 cementitious grout or epoxy mortar. Make the hole diameter 1/16 to 1/4 in. greater than the dowel or bolt diameter when using neat epoxy unless indicated otherwise by the epoxy manufacturer.

Thoroughly clean holes of all loose material, oil, grease, or other bond-breaking substance, and blow them clean with filtered compressed air. Use a wire brush followed by oil-free compressed air to remove all loose material from the holes, repeating as necessary until no more material is removed. Ensure holes are in a surface-dry condition when epoxy type materials are used and in a surface-moist condition when cementitious 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 pre-packaged systems.

Provide a Type III epoxy per DMS-6100, "Epoxies and Adhesives," when neat epoxy is used for anchor bolts or dowels. Provide Type VIII epoxy per DMS-6100, "Epoxies and Adhesives," 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 on the plans.

4.6.11. **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 with 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. Place concrete when the ambient temperature in the shade is at least 35°F and rising or above 40°F.

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

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 422.4.8., "Final Curing," during this period until all requirements for curing have been satisfied.

Have on hand all necessary heating and covering material, ready for use, before permission is granted to begin placement when impending weather conditions indicate the possible need for temperature protection. Distress caused by concrete drying out as a result of delayed set and strength gain associated with cold weather are a result of the Contractor's actions and are subject to repair in accordance with Section 422.4.10., "Defective Work."

4.6.12. **Placing Concrete in Hot Weather**. Use an approved Type B or D set retarding agent in all concrete for superstructures and top slabs of direct traffic culverts, except concrete containing slag cement, 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 above. Sprinkle and shade aggregate stockpiles or use ice, liquid nitrogen systems, or other approved methods as necessary to control the concrete temperature.

4.6.13. **Placing Concrete in Superstructure**. Place simple span bridge slabs without transverse construction joints by using either a self-propelled transverse finishing machine or a mechanical longitudinal screed unless otherwise shown on the plans. Use of manually operated screeding equipment may be permitted for small placements or for unusual conditions such as narrow widening, variable cross slopes, or transitions. 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. Release falsework under the spans before placing concrete on steel girder or truss spans, and swing the spans free on their permanent supports.

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

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

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.

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

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.

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

4.6.13.1. **Transverse Screeding**. Install rails for transverse finishing machines that are supported from the beams or girders so 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. Place concrete at a minimum rate of 30 ft. of bridge slab per hour for transverse screeding unless otherwise shown on the plans. Deposit concrete parallel to the skew of the bridge so all girders are loaded uniformly along their length. Deposit slab concrete between the exterior beam and 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. Start placement at the lowest end on profile grades greater than 1-1/2%.

At the Contractor's option, attach a pan drag and either a carpet or burlap drag to the screed assembly to float and provide surface micro-texture in one operation. Adjust the contact pressure of the pan drag to smooth high spots and fill any depressions left by the screed. Adjust the weight or position of the carpet or burlap drag to produce a smooth sandy micro-texture without blemishes, marks, or scratches deeper than 1/16 in. Fill screed rail support holes and holes from the Engineer's depth checks for slab thickness and reinforcing cover with concrete, and finish them to match the rest of the slab.

4.6.13.2. **Longitudinal Screeding**. 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 unless otherwise shown on the plans. 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. Start placing at the lowest end for spans on a profile grade of 1-1/2% or more. Use strips wide enough that the concrete within each strip remains plastic until placement of the adjacent strip. Place the concrete in proper sequence to be monolithic with the adjacent longitudinal strips of the slabs where monolithic curb construction is specified.

4.6.13.3. **Placements on Continuous Steel Units**. 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 unless otherwise shown on the plans. Retard the initial set of the concrete sufficiently to ensure 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. Ensure the previously placed concrete attains a compressive strength of 3,000 psi when staged placement of a slab is required on the plans before placing the next stage concrete. Multiple stages may be placed in a single day if approved. Use an approved placing sequence that will not overstress any of the supporting members where plans permit staged placing without specifying a particular order of placement.

4.6.13.4. **Slab and Girder Units**. Place girders, slab, curbs of slab, and girder spans monolithically unless otherwise shown on the plans. Fill concrete girder stems first, and place the slab concrete within the time limits specified in this Item. Place concrete in the stems for a short distance if using a transverse screed, and then place the concrete in transverse strips. Fill the outside girder stem first, beginning at the low end or side, if using a longitudinal screed, and continue placement in longitudinal strips.

4.7. **Finish and Interim Curing of Bridge Slabs**. Obtain approval of the proposed interim curing methods, equipment, and materials at the pre-pour meeting before placing concrete. Take into account forecast weather conditions to determine the interim curing methods to use.

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.

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 use of finish water.

Perform sufficient checks, witnessed by the Engineer, with a long-handled 10-ft. straightedge on the plastic concrete to ensure 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.

Provide a uniform micro-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. For bridge approach slabs the carpet drag, burlap drag, or broom finish may be applied either longitudinally or transversely.

Evaporation protection is required if the evaporation rate exceeds 0.10 lbs./sf./hr. based on the *Evaporation Calculation for Concrete Worksheet* as shown on the Department's website, the evaporation rate nomograph in the Portland Cement Association's *Design and Control of Concrete Mixtures* or if indicated on the plans.

4.7.1. **Evaporation Protection**. Use one of the following methods for evaporation protection.

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

4.7.1.2. **Wet Burlap**. Place pre-wet burlap no more than 10 ft. behind the finishing operation. A work bridge may be required to avoid marring the surface. Ensure the wet burlap covers the entire surface. Use sprayers, hoses, sprinklers, or other similar methods to keep the burlap continuously wetted until application of the final curing.

4.7.2. **Interim Curing**. Apply interim curing using one of the following options after applying the evaporation protection (if needed):

4.7.2.1. **Membrane Cure**. Apply membrane interim curing at a rate of approximately 180 sq. ft. per gallon. Apply before the water sheen disappears but do not place over standing water. Fog as necessary to maintain the wet sheen. Do not spray membrane curing on a dry surface.

4.7.2.2. **Wet Burlap**. Place pre-wet burlap no more than 10 ft. behind the finishing operation. Burlap used for evaporation protection will also be considered as the interim curing.

4.8. **Final Curing**. Obtain approval of the proposed curing methods, equipment, and materials at the pre-pour meeting before placing concrete. Inadequate curing or facilities may delay all concrete placements on the job until remedial action is taken. Apply final curing as soon as possible after interim curing without damaging the surface finish. Check the adequacy of the curing each day of the curing period. Take corrective action or modify the curing methods as needed to maintain a moist concrete surface.

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 superstructure concrete according to the following, unless otherwise shown on the plans:

- Concrete using Type I or III cement: 8 days
- Concrete using Type I/II or II cement: 10 days
- Concrete with any type of SCM: 10 days

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 provide insulation against cold weather. Supplemental heating or insulation may be required in cold and wet weather if the insulating cotton mats become wet or the concrete drops below the specified curing temperature. Avoid applying heat directly to concrete surfaces.

Use one of the following water curing methods for final curing. Keep all exposed surfaces of the concrete wet continuously for the required curing time. Use water for curing that meets the requirements for concrete mixing water in Section 421.2.5., “Water.” Do not use seawater or water that stains or leaves an unsightly residue.

4.8.1. **Cotton Mats**. Keep the concrete continuously wet by maintaining wet cotton mats in direct contact with the concrete for the required curing time. 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 outside air cannot enter the enclosure. Provide sufficient moisture inside the enclosure to keep all surfaces of the concrete wet. Use of soaker hoses and plastic covering is acceptable provided the concrete surface remains continuously wet for the required curing duration.

4.8.2. **Burlap Mats**. The burlap used for interim curing may also be used for final curing if kept continuously wetted and completely covered with plastic sheeting. Overlap plastic sheeting and weigh down sufficiently so air cannot get under the plastic.

4.8.3. **Burlap-Polyethylene Mats**. Place these mats over soaker hoses or other similar methods to keep the concrete surface wetted for the duration of the curing period. Overlap the mats and weight down sufficiently so air cannot get under the mats.

4.9. **Removal of Forms and Falsework**. 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 unless otherwise directed.

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. except as directed otherwise until the concrete has attained a compressive strength of 2,500 psi. Remove forms for other structural components as necessary.

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.

Apply an ordinary surface finish as the final finish to the bottom of bridge slabs between girders or beams, and vertical and bottom surfaces of interior concrete beams or girders unless otherwise noted.

Form marks and chamfer edges do not need to be smoothed for the bottom of bridge slabs between girders or beams. Remove all fins, runs, drips, or mortar from surfaces that will be exposed.

4.10. **Defective Work**. 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 determine locations where corrections are needed. Submit a plan for approval to produce a ride of acceptable quality if the Engineer determines the ride quality is unacceptable. Make all corrections for ride before saw-cutting grooves.

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.

The Engineer will inspect the deck or slab for plastic shrinkage and settlement cracking after completion of final curing and within 5 days after curing mats are removed. Seal any noted shrinkage cracks attributable to Contractor placing, curing, and finishing practices using gravity feed crack repair as directed in accordance with Item 780, “Concrete Crack Repair,” at no cost to the Department. Transverse cracks over interior bents in continuous slab units do not need to be sealed in this manner.

4.11. **Final Surface Texture**. 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 unless otherwise noted. Cut grooves perpendicular to the structure centerline. Cut grooves across the slab within 18 in. of the barrier rail, curb, or median divider. Adjust groove cutting at skewed metal expansion joints in bridge slabs by using narrow-width cutting heads so 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 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 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. Provide either a carpet drag or broom finish for micro-texture when saw-cut grooves are not required on the plans. In this case ensure an adequate and consistent micro-texture is achieved by applying enough weight to the carpet and keeping the carpet or broom from getting plugged with grout. For surfaces that do not have adequate texture, the Engineer may require corrective action including diamond grinding or shot blasting.

Give a carpet drag, burlap drag, or broom finish to all concrete surfaces to be overlaid when the plans call for a concrete overlay (CO) to be placed on the slab (new construction). 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. Revise finishing procedures to produce the desired texture if the texture depth falls below what is intended.

Give all concrete surfaces to be covered a lightly textured broom or carpet drag finish when the plans require an asphalt seal, with or without overlay, on the slab (new construction). Provide an average texture depth of approximately 0.025 in. when tested in accordance with Tex-436-A.

5. MEASUREMENT

Reinforced concrete slabs or decks on girders, beams, slab beams, double-T beams, or box beams placed under this Item will be measured by the square foot of slab surface area using the nominal dimensions and configuration shown on the plans. Transverse measurement will be made from outer edge of slab to outer edge of slab (including raised median and sidewalk sections). Longitudinal measurement will be made between ends of units or spans. Diaphragms, haunch concrete, reinforcement, and optional steel diaphragms will be considered as a portion of the slab unless otherwise shown. An estimated quantity for the haunch between the slab and beams will be included for the Contractor's information only. No measurement will be made during construction for variation in the amount of haunch concrete due to variations in camber of the beams.

Approach slabs and cast-in-place superstructure elements including flat slabs, slab and girder units (pan formed), and shear keys will be measured by the cubic yard. 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.

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 adjustment of quantities is required.

The quantities of concrete and reinforcing steel shown on the plans are based on a conventionally formed slab. These quantities include amounts for concrete diaphragms, brackets and other required attachments, and haunch concrete when required, based on the profile grade, theoretical camber, and dead load deflection of the beams. No additional measurement will be made for concrete or reinforcing steel due to a variation in camber of the beams from theoretical camber, or for additional quantities required by optional methods of forming.

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

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 superstructure elements specified. This price is full compensation for furnishing, hauling, mixing, placing, curing, and finishing concrete; furnishing and placing reinforcing steel; grouting and pointing; furnishing and placing drains and expansion joint material (except where specifically furnished under another Item); furnishing and placing metal flashing strips; forms (removable and permanent) and falsework; prestressed concrete panels; furnishing and placing concrete and reinforcement for raised medians, sidewalks, sign mounts, luminaire brackets, and other concrete appurtenances; removing designated portions of existing slab; cleaning, bending, and cutting exposed existing reinforcing steel; welding reinforcing steel; doweling; cleaning and preparing concrete surfaces; and equipment, labor, tools, and incidentals.

Price will be adjusted in accordance with Section 421.6., "Measurement and Payment," when required to address non-compliance of project acceptance testing.

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

Structural steel, anchor bolts, armor joints, sealed expansion joints, rail (including the concrete parapet portion), and concrete median barrier will be measured and paid for in accordance with pertinent bid items.

In addition to the work described above, for extending structures the unit prices bid is full compensation for removing and disposing of the designated portion of the existing structure; removing, stockpiling and replacing headwall units for reuse; cleaning, bending, and cutting of exposed reinforcing steel; splicing or

welding of new reinforcing steel to existing reinforcing steel; installation of dowels; and cleaning and preparing existing concrete surfaces.

Item 423
Retaining Walls

1. DESCRIPTION

Furnish, construct, and install retaining walls.

2. MATERIALS

2.1. **General**. Furnish materials in accordance with the following:

- Item 420, "Concrete Substructures,"
- Item 421, "Hydraulic Cement Concrete,"
- Item 440, "Reinforcement for Concrete,"
- Item 445, "Galvanizing,"
- Item 458, "Waterproofing Membranes for Structures," and
- Item 556, "Pipe Underdrains."

Use concrete for retaining walls that conforms to the requirements of Table 1 unless otherwise shown on the plans.

Table 1
Concrete for Retaining Walls

Application	Concrete
Cast-in-place, non-reinforced	Class A
Cast-in-place, reinforced	Class C
Precast	Class H, f'_c = 4,000 psi

Furnish concrete for machine-made concrete block units in accordance with ASTM C90, Class 1, Type II, except the minimum 28-day compressive strength must be 4,000 psi with maximum moisture absorption of 7%.

Provide Type 1 filter fabric in accordance with DMS-6200, "Filter Fabric." Provide filter fabric rated as UV-resistant when used as part of the exposed facing for a temporary wall.

Joint fillers, pads, waterstops, and other incidental materials must be as shown on the plans or approved by the Engineer.

Epoxy coat all steel used in concrete panels and coping including connectors, dowels, stirrups, and reinforcing steel when the plans call for epoxy coating of steel earth reinforcements.

2.2. **Definitions**. This Item uses the following terms:

- **Permanent Wall**. A retaining wall with a design service life of 75 years. All walls are presumed to be permanent walls unless otherwise specified on the plans.
- **Temporary Wall**. A retaining wall so designated by description, with a design service life of 3 years.
- **Mechanically Stabilized Earth (MSE) Wall**. A wall consisting of a volume of select backfill with tensile earth reinforcement elements distributed throughout. Permanent MSE walls use a precast concrete panel as a facing element. Temporary MSE walls use welded wire fabric with filter fabric backing as a facing element.
- **Concrete Block Wall**. A retaining wall that uses machine-made, precast concrete block units as facing elements. The walls may use a volume of select fill with tensile earth reinforcements distributed throughout, or may use only the facing unit and unit fill weight for support.

2.3. **Fabrication**.

2.3.1. **Cast-in-Place**. Meet Item 420, "Concrete Substructures."

2.3.2. **Formed Precast**. Meet Item 424, "Precast Concrete Structural Members (Fabrication)."

2.3.3. **Machine-Made Precast**. Furnish machine-made concrete block units in accordance with ASTM C90, sampled and tested in accordance with ASTM C140. Furnish units with molded dimensions within 1/8 in. of specified dimensions, except height must be within 1/16 in.

2.4. **Backfill**.

2.4.1. **Non-Select**. Furnish non-select backfill for walls other than temporary and permanent MSE and concrete block walls as indicated on the plans. Non-select fill will meet Item 132, "Embankment," of the type specified on the plans. Provide material with a maximum plasticity index of 30 if no type is specified as determined by Tex-106-E.

2.4.2. **Select**. Select backfill is required in specific areas of permanent and temporary MSE and concrete block-type retaining walls. Provide select backfill that is free from organic or otherwise deleterious materials and that conforms to the gradation limits shown in Table 2 as determined by Tex-401-A.

Provide backfill that does not contain shale, caliche, or other soft, poor-durability coarse aggregate particles. Reclaimed Asphalt Pavement (RAP) is not allowed. Crushed Concrete or manufactured sand is allowed for temporary walls with a service life of 3 years or less. Test each source of backfill for durability/soundness using Tex-411-A, 5-cycle magnesium sulfate soundness. Backfill material with a maximum 5-cycle soundness loss exceeding 25% will be rejected. Alternately, Tex-461-A, Micro-Deval abrasion may be used if the corresponding results show loss is not greater than 20%, otherwise Tex-411-A governs aggregate verification.

Type AS, BS, and DS particles larger than 1/4 in. must be angular or completely crushed. Provide mechanically crushed gravel or stone backfill. Gravel from each aggregate source will have a minimum of 95% two or more mechanically induced crushed faces, as Tex-460-A, Part I determines. Rounded rock or rounded gravel is not allowed. Natural sand meeting the requirements of this Section is permitted for use.

Table 2
Select Backfill Gradation Limits

Type	Sieve Size	Percent Retained
AS	3"	0
	1/2"	50–100
	#4	See Note
	#40	85–100
	#200	95–100
BS	3"	0
	#4	See Note
	#40	40–100
	#200	85–100
CS	3"	0
	#4	See Note
	#200	75–100
DS	3"	0
	3/8"	85–100
	#200	95–100

Note—Use No. 4 sieve for determination of rock backfill as described in this main paragraph, "Backfill."

When the backfill gradation results in 85% or more material retained on the No. 4 sieve, the backfill will be considered rock backfill. All Type DS backfill is considered rock backfill.

In addition to the requirements for Type CS select fill, the fraction finer than the No. 200 sieve must have a Plasticity Index (PI) in accordance with Tex-106-E not greater than 6.

Furnish Type BS backfill for permanent walls; Type CS backfill for temporary walls; and Type DS backfill for areas of walls subject to inundation unless otherwise shown on the plans, or below the 100-year flood elevation as noted on the plans.

Furnish backfill meeting the requirements of this Section but with a maximum particle size of 3/4 in. when nonmetallic or epoxy coated earth reinforcements are used.

2.4.3. **Drainage Aggregate**. Use drainage aggregate to fill the void within concrete block units and in the zone 1 ft. behind the units. Provide drainage aggregate that is free from organic or otherwise deleterious materials and that conforms to the gradation limits in Table 3 as Tex-110-E determines.

Table 3
Drainage Aggregate Gradation Limits

Sieve Size	Percent Retained
1"	0
3/4"	25–50
1/2"	50–100
#4	75–100

2.4.4. **Cement-Stabilized Backfill**. Use cement-stabilized backfill when required or as approved. Stabilize Type CS backfill with 5% hydraulic cement by dry weight of the backfill material. Use a stationary plant to thoroughly mix the backfill material, cement, and water. Place and compact the backfill within 2 hours of mixing. Provide special drainage provisions when cement-stabilized backfill is used, as shown on the plans.

2.4.5. **Electrochemical**. Provide backfill meeting the following additional requirements for permanent retaining wall systems using galvanized metallic earth reinforcements:

- The pH is between 5.5 and 10.0 as Tex-128-E determines.
- Resistivity is more than 3,000 ohm-cm as Tex-129-E determines.
- Material with resistivity between 1,500 and 3,000 ohm-cm may be used if the chloride content is less than 100 ppm and the sulfate content is less than 200 ppm as Tex-620-J determines.

Perform electrochemical testing on the raw, unstabilized backfill material when cement-stabilized backfill is used.

2.5. **Earth Reinforcements**. Furnish earth reinforcements that meet the design requirements. Galvanize or epoxy coat all steel elements for permanent walls in contact with soil. Epoxy coat in accordance with Item 440, “Reinforcement for Concrete,” except provide a minimum 18-mil coating thickness. Epoxy coat the reinforcing only when shown on the plans or as approved. Use connection hardware that is likewise nonmetallic or epoxy coated when using nonmetallic or epoxy coated earth reinforcements.

3. CONSTRUCTION

3.1. **General**. Construct retaining walls in accordance with details shown on the plans, on the approved working drawings, and to the pertinent requirements of the following Items:

- Item 110, “Excavation”
- Item 132, “Embankment”
- Item 400, “Excavation and Backfill for Structures”
- Item 420, “Concrete Substructures”
- Item 458, “Waterproofing Membranes for Structures”
- Item 556, “Pipe Underdrains”

Construct required piling or drilled shafts in accordance with the pertinent specification.

3.2. **Options**. When optional design details are shown on the plans, the Contractor is required to use the same facing design within an area of continuous retaining walls.

Provide drawings for review indicating the proposed design arrangement when proposing the use of 2 or more systems.

3.3. **Working Drawings**. When proprietary wall systems are used for permanent or temporary walls, submit casting drawings, construction drawings, and design calculations bearing the seal of a licensed professional engineer for review and approval following the Department's *Guide to Electronic Shop Drawing Submittal* process. Upon completion of construction, submit a set of reproducible as-built drawings.

3.3.1. **Casting Drawings**. Include all information necessary for casting wall elements, including railing and coping when prefabricated. Show shape and dimensions of panels; size, quantity, and details of the reinforcing steel; quantity, type, size, and details of connection and lifting hardware; and additional necessary details.

3.3.2. **Construction Drawings**. Include a numbered panel layout showing horizontal and vertical alignment of the walls as well as the existing and proposed groundlines. Include all information needed to erect the walls, including the proposed leveling pad elevations; the type and details of the soil reinforcing system (if applicable); the details and manufacturer of all pads, fillers, and filter fabric; the limits and dimensions of structural backfill; details necessary to incorporate coping, railing, inlets, drainage, and electrical conduit; and additional necessary details.

Leveling pad elevations may vary from the elevations shown on the plans. Provide at least 1 ft. of cover from the top of the leveling pad to finish grade unless a different minimum cover or a specified minimum leveling pad elevation is shown.

3.3.3. **Design Calculations**. Include calculations covering the range of heights and loading conditions on the project. Calculations for both internal and external stability as described on the plans will be required. Include a summary of all design parameters used; material types, strength values, and assumed allowables; loads and loading combinations; and factor-of-safety parameters.

3.4. **Permanent MSE Walls**. Grade the foundation for the structure level to a width equal or exceeding the length of the reinforcing system. Perform proof rolling on retaining wall foundation area to identify any loose, soft, or unsuitable materials in accordance with Item 216, "Proof Rolling." Material not meeting a maximum rut depth of 1 in. per pass of pneumatic tire roller should continue to be rolled or removed and replaced with suitable material. Pneumatic tire rolling will be waived for portions of wall with a reinforcement length of 8'; for these conditions proof rolling will be required with a smooth-wheeled vibratory roller or other approved roller.

Place drilled shafts and piling located within the MSE volume before construction of the wall. Place any required pipe underdrain before construction of the wall. Complete MSE wall construction before construction of abutment caps and abutment wing walls. Completion of walls and abutment should be in conjunction with project phasing or to allow for completion of walls that meets the proper placement and compaction at abutments.

Place the concrete leveling pad as shown on the construction drawings. Provide a wood float finish, and wait a minimum of 24 hr. before beginning panel erection. No curing or strength testing of the leveling pad concrete is required.

Shim the first row of panels as necessary to achieve correct alignment. Use plastic shims or other material that will not deteriorate. Remove and replace the leveling pad or provide a grout level-up as directed if the required shim height exceeds 1 in.

Place filter fabric behind the wall along the joint between the leveling pad and the panels. Grout areas where filter fabric spans more than 6 in. at leveling pad steps.

Place and compact fill material over the leveling pad to an elevation even with or above the surrounding ground after backfilling the first row of panels. Do not allow water to accumulate and stand at the base of the wall.

Place filter fabric behind all wall joints and at the intersection of retaining walls with other structures, including riprap. Cover joints at least 6 in. on each side and use adhesive to hold the filter fabric in place.

Exercise care while lifting, setting, and aligning panels to prevent damage to the panels. Discontinue any operation that results in chipping, spalling, or cracking of panels. Remove and replace damaged panels, or repair as approved by the Engineer.

Provide external bracing for the initial row of panels. Use wooden wedges, clamps, or other means necessary to maintain position and stability of panels during placement and compaction of backfill. Remove wooden wedges as soon as the panel or coping above the wedged element is erected and backfilled. Remove all wedges after completing the wall.

Review plumbness and position of each row of panels before placing the subsequent row. Remove and rebuild any portion of the wall that is out of tolerance. Modify panel batter and bracing, and backfill material, placement, and compaction methods as required to maintain wall tolerances.

Construct walls to a local vertical and horizontal alignment tolerance of 3/4 in. when measured along a 10-ft. straightedge relative to vertical and horizontal wall control line. Construct walls to an overall vertical tolerance (plumbness from top to bottom) of 1/2 in. per 10 ft. of wall height. Construct walls so the maximum offset at any panel joint is between 3/8 in. and 3/4 in. and no joint is open to the extent the filter fabric is visible from the front of the wall.

Place backfill to closely follow the erection of each row of panels. Place the select and embankment backfill to the same elevation where possible, and operate the compaction equipment over the interface. Do not create a continuous, distinct, vertical joint between the select and embankment backfill. Complete the embankment after construction of the retaining wall.

Maintain the stability of the interface area between the existing ground and the select fill when building a wall against existing ground. Remove and recompact any material that loosens, caves, or fails.

Compact backfill to provide at least 95% of density determined in accordance with Tex-114-E. Field density determination will be made in accordance with Tex-115-E.

Sprinkle backfill as required to ensure adequate uniformly distributed moisture in each lift before and during compaction. Place fill in lifts of 8 in. or less (loose measurement). Place fill in a manner that avoids segregation of the fill. Decrease the lift thickness if necessary to obtain the required compaction. Use hand-operated or walk-behind compaction equipment in the 3 ft. wide strip adjacent to the wall panels. Do not displace panels or distort or damage the reinforcement system during compaction. Modify backfill material, placement, and compaction methods as necessary to meet density requirements while maintaining wall tolerances.

Place rock backfill or material the Engineer determines too coarse for density testing in accordance with Section 132.3.4.1., “Ordinary Compaction.”

Place and compact the backfill to the reinforcement level, at each earth reinforcement level, before placing the reinforcement. Place earth reinforcements perpendicular to the face of the wall. Remove slack in connections before placing backfill. Pre-tension each layer of reinforcement to remove slack before placing backfill for systems using nonmetallic earth reinforcements. Use devices capable of mechanically applying and holding the required force. Do not operate tracked equipment directly on any reinforcement.

Cover the rock backfill with filter fabric before placing the 2 ft. of backfill immediately below the pavement structure or top of wall when rock backfill is used. Overlap the fabric at least 18 in. at splices, and extend it past the edge of the rock backfill at least 18 in. Use backfill that contains sufficient fines to fill the voids in a

compacted state above the filter fabric. Place a horizontal layer of filter fabric as noted above when transitioning from rock backfill to finer grained backfill anywhere within the wall volume.

Prevent surface water or rainwater from damaging the retaining walls during construction. Shape the backfill to prevent water from ponding or flowing on the backfill or against the wall face. Remove and replace any portion of the retaining wall damaged or moved out of tolerance by erosion, sloughing, or saturation of the retaining wall or embankment backfill.

3.5. **Temporary MSE Walls**. Provide a facing system rigid enough to maintain a smooth and straight wall face both during and after construction.

Grade and compact the foundation for the structure as described in Section 423.3.4., "Permanent MSE Walls."

Place earth reinforcement and facing system in accordance with the approved working drawings. Backfill the 2-ft. zone immediately behind the facing with clean, coarse rock meeting the requirements of Coarse Aggregate Grade 1, 2, or 3 of Item 421, "Hydraulic Cement Concrete," or of Type DS backfill as described in Section 423.2.4.2., "Select." Cement-stabilized backfill as described in Section 423.2.4.4., "Cement-Stabilized Backfill," may be used in place of the coarse rock.

Place and compact backfill in accordance with Section 423.3.4., "Permanent MSE Walls."

Construct walls to a vertical and horizontal alignment tolerance of 3 in. when measured along a 10-ft. straightedge. Construct walls to an overall vertical tolerance (plumbness from top to bottom) of 2 in. per 10 ft. of wall height. Place adjacent facing elements so the maximum out-of-plane offset at any facing element joint is less than 1 in. Place facing elements and filter fabric with no gaps in the facing or fabric.

Prevent surface water or rainwater from damaging the retaining walls during and after construction. Place temporary berms or curbs, shape the backfill, or use other approved methods to prevent water from flowing against or over the wall face. Remove and replace any portion of the wall damaged or moved out of tolerance by erosion, sloughing, or saturation of the retaining wall or embankment backfill.

3.6. **Concrete Block Retaining Walls**. The concrete block units may be sampled and tested by the Engineer before shipment or upon delivery to the construction site. Display for approval, samples of block units indicating the color, texture, and finish. Store, transport, and handle all block units carefully to prevent cracking or damage.

Grade and compact the foundation for the structure, and place the leveling pad as described in Section 423.3.4., "Permanent MSE Walls."

Place the concrete block facing units in accordance with the approved working drawings. Fill the voids within the units and fill the 1-ft. zone immediately behind the facing with drainage aggregate as described in Section 423.2.4.3., "Drainage Aggregate." Systems tested without unit fill may omit the fill as indicated on the approved drawings. Systems with approved filter fabric details may omit the drainage aggregate in the 1-ft. zone immediately behind the facing.

Place reinforcements and backfill for walls using earth reinforcements in accordance with the requirements of Section 423.3.4., "Permanent MSE Walls." Pay particular attention to the connection details of the earth reinforcements to the concrete block units.

Construct walls to a vertical and horizontal alignment tolerance of 1-1/2 in. when measured along a 10-ft. straightedge. Construct walls to an overall vertical tolerance (deviation from the vertical or battered control line, top to bottom) of 1 in. per 10 feet of wall height. Place adjacent facing elements so the maximum out-of-plane offset at any facing element joint is less than 1 in. Place facing elements with maximum 1/4-in. gaps between block units.

Prevent surface water or rainwater from damaging the retaining walls during construction. Shape the backfill to prevent water from ponding or flowing on the backfill or against the wall face. Remove and replace all portions of the retaining wall damaged or moved out of tolerance by erosion, sloughing, or saturation of the retaining wall or embankment backfill.

4. MEASUREMENT

This Item will be measured by the square foot of the front surface area of the wall. Unless otherwise shown on the plans, the area will be measured from 1 ft. below finished grade of the ground line on the face of the exterior wall to the top of the wall including any coping required (not including railing).

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.

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 "Retaining Walls" of the type or special surface finish specified. This price is full compensation for excavation in back of retaining walls and for footings; furnishing and placing footings, leveling pads, copings, and traffic railing foundations; furnishing, placing, and compacting backfill (except in embankment areas), including cement for stabilization; proof rolling; furnishing and placing concrete, reinforcing steel, waterproofing material, filter material and drain pipe, joint material, water stop, and filter fabric when required; fabricating, curing, and finishing all panels; furnishing and placing earth reinforcement, anchorage systems, and fasteners; wall erection; and equipment, labor, tools, and incidentals.

Retaining wall backfill areas that are also in embankment areas will be considered part of the quantities measured and paid for under Item 132, "Embankment."

When drilled shafts are required, they will be measured and paid for as specified in Item 416, "Drilled Shaft Foundations." When piling is required, it will be measured and paid for as specified on the plans for piling of the appropriate type.

Item 429
Concrete Structure Repair

1. DESCRIPTION

Remove and repair unsound, delaminated, or spalled concrete.

2. MATERIALS

Submit all proposed repair materials for approval. Provide materials as outlined in the *Concrete Repair Manual* and in accordance with the requirements of the following Items.

- Item 421, "Hydraulic Cement Concrete,"
- Item 431, "Pneumatically Placed Concrete,"
- Item 440, "Reinforcement for Concrete,"
- DMS-4655, "Concrete Repair Materials," and
- DMS-6100, "Epoxies and Adhesives."

2.1. **Concrete Repair Materials**. Provide repair materials suitable for the appropriate horizontal, vertical, or overhead application meeting the requirements in DMS-4655, "Concrete Repair Materials." Use Type C trowel-applied materials in vertical and overhead applications less than 3" unless otherwise shown on the plans. Use neat Type A (Rapid) or Type D (Standard) materials in horizontal or form-and-pour applications less than 3" thick and extended Type A or Type D for repairs exceeding 3" in depth. Type D repairs should be used in lieu of Type A when rapid strength gain is not necessary. Use Type B ultra-rapid hardening materials only if shown on the plans. The Engineer may disallow any product based on its structural compatibility.

2.2. **Pneumatically Applied Materials**. Pneumatically applied concrete or mortar may be used, if approved, for any repair thickness. Provide and place pneumatically applied concrete in accordance with Item 431, "Pneumatically Placed Concrete." Prepare trial batches of any proposed repair material and application method as directed.

2.3. **Epoxy Mortars**. Use Type VIII neat epoxy or epoxy mortar per DMS-6100, "Epoxies and Adhesives," for repairs less than 1 in. thick unless noted otherwise on the plans.

2.4. **Concrete**. Provide Class C concrete for substructures, Class S concrete for decks, or concrete of the specified design strength unless noted otherwise as follows:

- as an option for vertical/overhead repairs greater than 6 in. thick;
- for full or partial depth slab repairs;
- for replacement of entire members or elements;
- as an option for horizontal repairs greater than 4 in. thick.

Submit a mix design for approval in accordance with Item 421, "Hydraulic Cement Concrete," unless otherwise shown on the plans. Include all pertinent information on admixtures. Do not use corrosion-inhibiting admixtures unless indicated on the plans or approved.

2.5. **Steel**. Provide steel pins, studs, or expansion bolts with a minimum diameter of 1/8 in. and a minimum length of 2 in. to attach reinforcement at the locations shown on the plans or as directed. Provide reinforcing steel, either welded wire fabric or reinforcing bars, as required by this Item or as shown on the plans.

3. CONSTRUCTION METHODS

Follow the procedures outlined in the *Concrete Repair Manual* unless approved otherwise. The Contractor may propose alternate repair methods for review and approval before commencing work.

Submit for approval all materials and methods of application at least 3 weeks before beginning any repair work.

Repair locations will be indicated on the plans or by the Engineer.

3.1. **Crack Repair**. Repair cracks in accordance with Item 780, "Concrete Crack Repair."

3.2. **Repair of Defective Work**. Repair or replace defective areas and patched areas that have debonded after completion of curing, as directed, at the Contractor's expense.

4. MEASUREMENT

This Item will be measured by the square foot, in place, as measured on the specified horizontal, vertical, or overhead surfaces of the completed repair as shown below or by the cubic yard for full element or member replacement. When a repair involves multiple surfaces, such as a corner, measurement will be made of all surfaces repaired. Bridge deck repairs will be measured by the square foot in place of the completed repair.

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 Structure Repair" of the kind specified. This price is full compensation for furnishing, placing, and curing all repair materials; removing concrete; saw-cutting; cleaning reinforcing steel; supplying and installing replacement or supplemental reinforcing steel, drive pins, studs, or expansion bolts; and equipment, labor, and incidentals.

Item 439
Bridge Deck Overlays

1. DESCRIPTION

Overlay concrete bridge deck surface with concrete overlay (CO), latex-modified concrete overlay (LMC), or multi-layer polymer overlay (MLPO).

2. MATERIALS

Provide materials conforming to the pertinent requirements of the following Items except as noted below.

- Item 421, "Hydraulic Cement Concrete," and
- Item 440, "Reinforcement for Concrete."

2.1. **Latex for LMC**. Provide latex admixture meeting the requirements of DMS-4640, "Chemical Admixtures for Concrete."

Store latex at temperatures between 40°F and 85°F. Do not allow latex to freeze.

2.2. **Grout for CO or LMC**. Provide grout for bonding new concrete to existing concrete consisting of equal parts by weight of hydraulic cement and sand when shown on the plans. Mix with sufficient water to form a stiff slurry, which can be applied with a stiff brush or broom to the existing concrete in a thin, even coating that will not run or puddle in low spots.

2.3. **Materials for MLPO.**

2.3.1. **Crack Sealant**. Furnish epoxy crack sealant conforming to DMS-6100, "Epoxies and Adhesives," Type IV, and compatible with the multiple layer polymer overlay determined by the manufacturer of the overlay system. Epoxy, methacrylate, or polymer crack sealant not meeting the requirements of DMS-6100, "Epoxies and Adhesives," for Type IV epoxy may be used if part of the manufacturer's overlay system.

2.3.2. **Sand**. Furnish finely graded, oven-dry mason's sand (for broadcast over crack sealant) that is compatible with the multiple layer polymer overlay determined by the manufacturer of the overlay system.

2.3.3. **Aggregate**. Furnish aggregate (for polymer overlay) that conforms to the gradation specified in Table 1. Use an angular-shaped aggregate with a Mohs scale hardness of 6 or greater. Use aggregates that are non-friable, non-polishing, clean, kiln-dried to a maximum moisture content of 0.2% by weight, and free of dirt, clay, asphalt, and other organic materials. All aggregate materials retained in the #8 sieve must have at least 1 mechanically fractured face. Aggregate not meeting the gradation requirements in Table 1 may be accepted if part of an overlay system.

Table 1
Aggregate Gradation Requirements[1]

	Sieve #4	Sieve #8	Sieve #16	Sieve #30
% by weight passing sieve	100%	30–75%	0–5%	0–1%

1. Based on the washed sieve analysis given in Tex-200-F, Part II.

2.3.4. **Resin for Polymer Overlay**. Furnish a polymer resin composed of epoxy, modified epoxy or methyl methacrylate (MMA). The resin (neat) and resulting polymer overlay system (composite consisting of resin and aggregate) must comply with the property requirements specified in Table 2. Furnish a 2-component, 100% solid, 100% reactive resin free of volatile solvents for epoxy-based resin. Formulate the resin to volumetric mixing proportions such as 1 part "A" to 1 part "B" according to the overlay system manufacturer's

recommendations. Furnish a flexibilized methyl methacrylate (Component A) and a powdered hardener (Component B) for MMA resin.

Table 2
Requirements for Resin and Polymer Overlay System

Property	Requirement[1]	Test Method
Viscosity (neat)	7–70 poises	Tex-614-J
Gel time (neat)	15 min. minimum	Tex-614-J
Compressive strength at 5 hr. (composite)	1,000 psi minimum	Tex-618-J
Compressive strength at 48 hr. (composite)	3,000 psi minimum	Tex-618-J
Tensile strength at 7 days (neat)	1,800–5,000 psi	Tex-618-J
Resilience at 48 hr. (neat)	70% minimum	Tex-618-J
Elongation at 7 days (neat)	30% minimum	Tex-618-J
Bond Strength (neat)	250 psi minimum	Tex-614-J
Shore D hardness (neat)	60–70	ASTM D2240
Absorption at 24 hr. (neat)	1% maximum	ASTM D570
Thermal compatibility (composite)	No delamination of overlay	ASTM C884 with modifications; one cycle is 8 hr. at 60°C followed by16 hr. at -21°C. Determine results after 9 cycles.

1. Values are based on composite specimens or neat samples cured or aged and tested at 24°C (75°F).

3. EQUIPMENT

3.1. **Surface Preparation Equipment**.

3.1.1. **Concrete Removal and Surface Preparation**. Provide equipment meeting the requirements of Item 483, "Concrete Bridge Deck Surfacing."

3.1.2. **Abrasive Blasting**. Provide equipment capable of removing oil, dirt, slurry, curing compound, laitance, etc., from the surface of the concrete.

3.1.3. **Sawing**. Provide equipment capable of sawing concrete to the specified depth when required.

3.1.4. **Power-Driven Chipping Tools**. Provide tools not heavier than a nominal 30 lb. class for bulk removal of concrete.

3.1.5. **Chipping Hammers**. Provide chipping hammers not heavier than a nominal 15 lb. class to remove concrete beneath any reinforcing bars.

3.1.6. **Cleaning**. Provide magnetic equipment followed by vacuum equipment to remove spent steel shot. Provide vacuum equipment for final cleaning of prepared surfaces unless otherwise approved.

3.1.7. **Test Apparatus for MLPO**. Provide all equipment to perform tensile adhesion test prescribed in ASTM C1583.

3.2. **Proportioning and Mixing Equipment**.

3.2.1. **Grout Mixer**. Provide a volumetric continuous or mortar mixer.

3.2.2. **Concrete Overlay**. Follow applicable provisions of Item 421, "Hydraulic Cement Concrete."

3.2.3. **Latex-Modified Concrete Overlay**. Follow the applicable provisions of Item 421, "Hydraulic Cement Concrete." Proportion and mix the latex-modified concrete at the project site using a suitable approved mixer capable of thoroughly mixing the ingredients to a uniform consistency.

3.2.4. **Multi-Layer Polymer Overlay**. Furnish equipment suitable for mixing and placing the overlay system components recommended by the manufacturer of the overlay system. Furnish paint rollers or notched squeegees to apply crack sealant and resin.

Provide aggregate spreading equipment or methods capable of uniformly applying the aggregate so 100% of the polymer material is covered to excess.

3.3. **Placing and Finishing Equipment**.

3.3.1. **Hand Tools**. Provide sufficient hand tools for placing, consolidating, striking off, and finishing stiff plastic concrete.

3.3.2. **Finishing Equipment for Concrete Overlay**. **Provide an approved surface vibrator moving ahead of the finishing** machine or an approved vibrating screed for overlay consolidation. Provide work bridges or other suitable facilities to perform all finishing operations.

3.3.3. **Finishing Equipment for Latex-Modified Concrete Overlay**. Provide a mechanical strike-off to ensure a uniform thickness of concrete in front of the screed. Design the bottom face of the screed to minimize tearing of the surface of the plastic concrete.

Provide a finishing machine capable of forward and reverse motion under positive control. Make appropriate provisions for raising the screeds to clear the screeded surface for traveling in reverse. Equip the finishing machine to travel on and screed off of any adjacent completed lane without damaging it. Use approved manual screeds and vibrators to consolidate and finish small or irregular areas inaccessible to the finishing machine. Provide work bridges or other suitable facilities to perform finishing operations and density checks.

4. CONSTRUCTION OF CONCRETE OR LATEX MODIFIED CONCRETE OVERLAYS

4.1. **General**. Provide for approval a detailed work plan including equipment and manpower before beginning any work.

The Engineer will inform the Contractor if night placements become necessary. No additional compensation will be provided for night placements of concrete. Provide sufficient lighting to make quality workmanship and adequate inspection possible during night placements. Lighting must be approved before operations begin.

Provide sufficient labor and equipment for proportioning, mixing, placing, and finishing concrete overlay at a rate of at least 40 ft. of finished overlay per hour. Do not allow traffic other than construction equipment for the overlay on any portion of the prepared bridge deck before the overlay has been placed. Provide side and end forms for supporting the screed and containing the overlay concrete. Provide reinforcement, when required, in accordance with Item 440, “Reinforcement for Concrete,” and the details shown on the plans.

Place concrete only when the air or deck temperature is 40°F or above and the concrete temperature is between 50°F and 85°F. Do not cart concrete batches over the completed overlay until the overlay concrete has attained a 3,000-psi compressive or 425-psi flexural strength. If carts are used, provide timber planking of at least 3/4 in. thickness for the remainder of the curing period. Provide carts equipped with pneumatic tires. Do not interrupt curing operations for the purpose of carting concrete over finished slabs.

Open the structure with the completed overlay to normal construction traffic or to the traveling public in accordance with Section 422.4.1., “Schedule Restrictions and Inspection Hold-Points.”

4.2. **Classification and Mix Design**. Provide a mix design in accordance with Item 421, “Hydraulic Cement Concrete.” Use a water reducing chemical admixture as necessary to achieve the desired consistency without exceeding the specified water to cementitious material ratio. Provide a mix design with an entrained air content of the fresh concrete of 6% with a tolerance of ±1% when tested in accordance with Tex-414-A or Tex-416-A together with the following requirements:

4.2.1. **Concrete Overlay**. Provide Class CO concrete with a coarse aggregate factor of at least 0.55.

4.2.2. **Latex-Modified Concrete**. Provide Class LMC concrete with a cement content of at least 658 lb. per cubic yard, a latex admixture content of at least 24.5 gal. per cubic yard, and a water content of no more than 18.9

gal. per cubic yard. Provide a mix design using a coarse aggregate volume of 30% to 45% by weight of the total aggregate and a weight ratio of cement-to-sand to coarse aggregate of 1.0:2.8:1.7 based on aggregate in a saturated surface-dry condition. Use a commercially available antifoaming agent with the polymer modifier as necessary to control the air content in the mix.

4.3. **Surface Preparation**. Do not scarify concrete surfaces with a grooved or tined finish unless shown on the plans. Prepare these surfaces by abrasive blasting or water-injected abrasive blasting as required to remove dirt, oil, curing compound, laitance, surface mortar, and other material that would inhibit bonding of the overlay, but leave the striations intact.

Scarify the surfaces of slabs to be rehabilitated to the depths shown on the plans using the method specified in accordance with Item 483, “Concrete Bridge Deck Surfacing.”

Remove and dispose of deteriorated or delaminated areas of concrete as shown on the plans or as determined by the use of a sounding hammer, chain drag, or other acceptable device, and by visual inspection after scarifying as approved.

Remove and repair deteriorated concrete below the indicated depth of scarification in accordance with Item 429, “Concrete Structure Repair.” Use only hydraulic-cement concrete for these repairs. Ensure the repaired surface is flush with the surrounding scarified surfaces. Allow the repair concrete to cure before placing the overlay concrete unless approved otherwise. When approved, placing repair concrete in partial depth deck repairs may be done concurrently when placing the overlay concrete.

Use a jackhammer not heavier than a nominal 30 lb. class to remove deteriorated concrete in small areas not accessible to the mechanical scarifier, and to spot-remove small areas of deteriorated concrete to a depth down to the existing top reinforcing steel. This class of jackhammer may also be used for concrete removal between existing reinforcing bars to a greater depth. Use chipping hammers not heavier than a nominal 15 lb. class to remove concrete from beneath any reinforcing bars near the perimeter of the removal area. Avoid cutting, stretching, or damaging exposed reinforcing steel by direct impact of these power tools. Repair or replace reinforcing steel damaged during the concrete removal process at no additional expense to the Department. Operate all jackhammers and chipping hammers at an angle of 45° or less measured from the surface of the slab.

Remove the concrete surrounding the reinforcing bars to a minimum depth of 1/2 in. below the bar to permit the new concrete to bond to the entire periphery of the exposed bar if reinforcing steel is exposed during bridge deck surfacing.

Clean all exposed reinforcing steel, scarified surfaces, and newly exposed concrete surfaces including construction joints against curbs or parapet walls by wet or dry abrasive blasting. Blast corroded reinforcing steel to gray metal. Remove and place all blast debris in an approved disposal site. Repair or replace damaged reinforcing steel as required.

Place, support, and tie new reinforcing steel on prepared surface in accordance with Item 440,“Reinforcement for Concrete,” when shown on the plans.

4.4. **Placing and Finishing Concrete**. Grade the screed rails or headers to ensure the concrete is finished to the required profile. Place the rails or headers outside the area to be overlaid unless otherwise approved. Provide anchorage of headers or supporting rails for horizontal and vertical stability as necessary. A hold-down device anchored into the concrete will not be permitted unless the concrete is to be subsequently overlaid. Obtain approval for plans for anchor support of headers or rails before beginning work.

Provide the overlay thickness specified on the plans. Adjust the screed and screed rail as necessary to provide the approved grade and required thickness. Check the clearance between the screed and existing surface for nonreinforced overlays by attaching a filler block with a thickness of 1/8 in. less than the overlay thickness to the bottom of the screed. Pass the screed over the area to be overlaid with the filler block in place. Correct any areas with insufficient clearance by adjusting the screed and rail system or by chipping or

scarifying as approved by the Engineer. Check screed clearance and reinforcement cover for reinforced overlays as approved by the Engineer.

Construct longitudinal joints at locations shown on the plans or as approved. Construct a straight and vertical edge at transverse and longitudinal construction joints. Saw joints before placing the adjacent overlay course.

Install expansion joints in the overlay at the same locations as the expansion joints in the deck.

Provide clean surface before moistening surface to receive overlay by clean air blasting or water blasting to remove all dust, spent abrasives, laitance, and other contaminants that can reduce bond strength of overlay to concrete surface.

Moisten the prepared surface to a near saturated surface-dry condition just before placing the overlay concrete. Remove standing water from the surface before placing the overlay concrete.

Do not use bonding grout unless otherwise required on the plans or by this Item. When bonding grout is required, moisten the prepared surface to a near saturated surface-dry condition before placing bonding grout. Scrub a thin coating of grout into the prepared surface immediately before placing the concrete. Ensure all surfaces including vertical joints receive a thorough, even coating and that no excess grout collects in pockets. Apply the grout so it does not become dry before it is covered with concrete.

Coat areas of the bridge deck where concrete has been removed below the top mat of reinforcing steel with bonding grout if required, and fill them with overlay concrete or Class S concrete as applicable to cover the reinforcing steel, if deck repairs were not previously finished. Adequately consolidate and rough float these areas just ahead of the overlay placement. Stop all operations if grout dries out, and remove the grout using high-pressure water blasting.

Place and mechanically strike off the overlay concrete slightly above the final grade. Follow this strike-off by mechanically consolidating and screeding the surface to the final grade. Vibrate all concrete into the corners and angles of the edges. Hand-finish the surface with a float as necessary to produce a tight, uniform surface.

Assure dense, watertight construction joints by properly consolidating the concrete and float-finishing the top surface of the joint flush with the adjacent concrete.

Meet the straightedge and finishing requirements specified in Section 422.4.7., “Finish and Interim Curing of Bridge Slabs,” for the finishing of the concrete overlay.

4.5. **Curing**. Apply wet-burlap to cure the overlay as soon as possible after the concrete has been textured. Overlay that dries out or cracks before the wet burlap is applied will be rejected. Keep the burlap continuously wet for 48 hr. for LMC and for 4 days for CO overlays. Allow LMC overlay to air cure for an additional 48 hr. before opening to traffic. Water-cure the CO overlay in accordance with Section 422.4.8., “Final Curing,” for an additional 4 days. Do not place traffic on overlay until required strength is obtained. Maintain the surface temperature of the concrete above 40°F for the required curing period. Remove and replace rejected overlay concrete at no additional cost to the Department.

4.6. **Final Surface Texture**. Provide final surface texture to hardened concrete surface when required and in accordance with Section 422.4.11, “Final Surface Texture.”

5. CONSTRUCTION FOR MULTI-LAYER POLYMER OVERLAY

5.1. **Contractor Submittals**. Submit to the Engineer the following documentation, and obtain approval before work commences:

5.1.1. **Product Data**. Submit a list of materials to be used. Provide manufacturer's product data sheets that include: material specifications for the proposed polymer overlay system; mechanical, physical, and chemical properties; environmental durability; limitations; maintenance instructions; and general recommendations on storage, mixing, application, cleanup, and disposal of materials. Submit a resin mix design which includes the name and type of all ingredients, the mix ratios to be used, and the application rate for each material. Include in the submittal a chart showing the expected cure times (in minutes) at the corresponding temperatures between 40°F and 100°F (in 10°F increments) for the proposed mix designs.

5.1.2. **Certification of Compliance**. Provide a certificate of compliance from an independent, nationally recognized laboratory stating the materials to be used meet the requirements of this specification. Furnish samples of the materials to be used as required by the Engineer.

5.1.3. **Material Safety Data Sheets**. Provide manufacturer's Material Safety Data Sheets (MSDS) for all materials to be used on site and certification the materials conform to local, state, and federal environmental and worker's safety laws and regulations.

5.1.4. **Work Plan**. Submit a work plan for constructing the overlay including at least the following: proposed equipment, materials, and procedures for preparing the surface and placing the overlay; proposed removal and replacement of existing non-compatible deck repair materials; repair procedures for patching deteriorated areas and repairing cracks exposed by surface preparation; and an anticipated schedule for traffic control. The work plan must meet the approval of the manufacturer of the polymer overlay system. Any deviations from the application prescribed by this specification must be approved.

5.1.5. **Technical Support Representative**. Submit name and qualifications of overlay system manufacturer's representative who will be on the jobsite at initiation of work. The Engineer may request the manufacturer's representative return to the jobsite to address issues that may arise during the work.

5.2. **Handling of Materials**. Transport and store polymer materials in their original containers in accordance with the manufacturer's recommendations and requirements. Clearly mark containers as "Part A—Contains Resin" or "Part B—Contains Curing Agent," and include the following information on each container: name of product, name and address of manufacturer, mixing proportions and instructions, lot and batch numbers, date manufactured, and quantity contained. Store aggregates in a clean and moisture-free atmosphere that is protected from all potential sources of contamination.

5.3. **Deck Repair**. Repair the deck in accordance with Item 429, "Concrete Structure Repair," before surface preparation and if indicated on the plans. Use only repair materials that are compatible with the crack sealant and overlay systems the system manufacturers' determined. Do not use phosphate-based repair materials unless the overlay system manufacturer determines them to be compatible.

5.4. **Surface Preparation**. Prepare the entire concrete deck surface after all repairs have cured in accordance with the repair material manufacturer's recommendations by removing weak concrete, asphaltic materials, oils, dirt, rubber, curing compound, paint, carbonation, laitance, weak surface mortar, and other potentially detrimental materials that, in the opinion of the overlay system manufacturer's representative or the Engineer, would prevent proper bonding to or curing of the overlay material. Use power-driven hand tools only in areas where mechanical surface preparation equipment cannot reach. Conduct all hand tool operations before using mechanical surface preparation equipment. Select a surface preparation technique such as size and flow of abrasive or water pressure, travel speed, and number of passes that will provide a surface profile equivalent to ICRI Guide No. 03732, Profile 5 or higher. Use advanced surface removal methods in accordance with Item 483, "Concrete Bridge Deck Surfacing," when shown on the plans.

Use compressed air equipment to clean all dust, debris, and concrete fines from the deck surface and vertical faces of curbs and barrier walls up to a height of 1 in. above the overlay after hand tool and mechanical surface preparation is complete.

Do not allow public traffic onto any portion of the deck that has been prepared and cleaned, or onto any area where all courses have not been placed and allowed to fully cure. Overlay application equipment only is

allowed to drive on the prepared deck surface or on any intermediate course during the overlay application as long as these surfaces are not contaminated or otherwise damaged.

Protect all prepared surfaces from subsequent contamination, and remove any contamination found on the deck or intermediate courses after initial preparation. The deck surfaces will be inspected for presence of contaminants immediately before placing sealant or any course of the overlay system. Apply the sealant or first course of the overlay within 24 hr. of surface preparation, and place all intermediate courses of the overlay within 7 days of initial surface preparation.

5.5. **Tensile Adhesion Testing**. Conduct direct pull-off tests in accordance with ASTM C1583 to determine the adequacy of the selected surface preparation (size of shot, flow of shot, forward speed of blast machinery, number of passes, blast pressure, etc.) and cleaning methods. Conduct these tests when the surface temperature is below 80°F. Core through the test overlay to a depth of 0.5 in. into the underlying concrete.

Conduct one tensile adhesion test for each span or 500 sq. yd. whichever is smaller. The Engineer will determine test site locations for each representative portion of deck. In addition to representative portion tests, the Department may require additional tensile adhesion tests be performed on areas inaccessible to mechanical surface preparation equipment. The Contractor must remove residual test materials adhering to the deck, make necessary adjustments to the surface preparation methods, and retest all representative portions with failing test results, at no additional cost to the Department, until one passing tensile adhesion test result (from 3 pull-off tests) is obtained for each area tested.

One tensile adhesion test result is the average of 3 pull-off tests conducted over a 1 ft. × 3 ft. test site prepared with at least 1 layer of polymer. Surfaces with tension adhesion test results demonstrating average tensile bond strengths of at least 250 psi are considered acceptable.

5.6. **Application of Crack Sealant**. Apply the crack sealant in conjunction with the first layer of polymer overlay if the crack sealant and overlay system manufacturers determine it is compatible and the Engineer approves. Do not place crack sealant on new hydraulic cement concrete that is less than 28 days old unless the overlay system manufacturer allows it in writing. Allow the deck and all cracks to dry fully before applying crack sealant. Place the crack sealant on repairs only after completion of curing of the repair material and with the concurrence, in writing, of the polymer overlay system manufacturer. Identify moisture in the deck using a plastic sheet left taped in place for a minimum of 2 hr. (per ASTM D4263) or other approved methods.

Mix, place, and cure the crack sealant in accordance with the sealant manufacturer's written recommendations. Do not apply crack sealant if the ambient air temperature is expected to drop below the sealant manufacturer's recommended application temperature range within 8 hr. after application or if the gel time is expected to drop below 10 min.

Broadcast sand at the rate recommended by the sealant manufacturer in such a manner that complete coverage of the treated area is attained while the crack sealant is still tacky. Cure treated area until vacuuming or sweeping can be conducted without tearing or otherwise damaging the treated surface.

Repair at no additional cost to the Department any areas in which the treated surface is damaged, contaminated, or does not receive adequate sand embedment before gelling to create a surface compatible with the overlay system as the overlay system manufacturer determines.

5.7. **Application of Polymer Overlay**. Do not place polymer overlay on new hydraulic cement concrete that is less than 28 days old unless otherwise approved. Place polymer overlay on repairs only after completion of curing of the repair material and with the concurrence, in writing, of the polymer overlay system manufacturer. Allow the deck to dry fully before applying polymer overlay. Identify moisture in the deck using a plastic sheet left taped in place for at least 2 hr. (per ASTM D4263) or other approved methods. Remove all loose sand or aggregate, and attain approval from the Engineer before placement of each polymer overlay course.

Mix, place, and cure the polymer overlay materials in accordance with the overlay system manufacturer's written recommendations. Do not apply polymer overlay if the ambient air temperature is expected to drop

below the overlay system manufacturer's recommended application temperature range within 8 hr. after application or if the gel time is expected to drop below 10 min. MMA overlays may be placed as a slurry, with resin and aggregate pre-mixed, in accordance with the manufacturer's recommendations.

Broadcast aggregate onto the still fluid resin binder until a dry layer of aggregate is present over the entire surface. Immediately broadcast additional aggregate until a dry surface is established if wet spots develop. Accomplish all aggregate broadcasting while binder is still fluid. Cure each course of overlay until vacuuming or sweeping can be conducted without tearing or otherwise damaging the overlay surface. Repair at no additional cost to the Department any intermediate courses in which the treated surface is damaged, contaminated, or does not receive adequate aggregate before gelling to create an intermediate surface compatible with the next overlay course as the overlay system manufacturer determines. Repair damaged areas in accordance with the overlay system manufacturer's recommendations at no additional cost to the Department if the final polymer overlay surface is damaged or marred.

The nominal finished overlay thickness is at least 3/8 in. measured from the highest point on the deck surface to the peaks of the aggregate. Apply the polymer with aggregates in multiple courses (minimum of 2 for epoxy systems, and at least one course for slurry applied MMA) as prescribed by the overlay system manufacturer but at rates no less than specified in Table 3. Stagger and overlap longitudinal joints between successive courses so no ridges form.

Table 3
Polymer and Aggregate Application Rates

Course	Polymer (gal./100 sq. ft.)	Aggregate (lb./sq. yd.)
Epoxy 1	Not less than 2.5	> 10
Epoxy 2	Not less than 5.0	> 14
MMA 1	Not less than 4.0	> 13

Protect all bridge deck expansion joints from intrusion of polymer overlay materials. Remove overlay over all expansion joints within 12 hr. of application and before opening the overlay surface to traffic. Removal may be accomplished by scoring the overlay before gelling, by saw-cutting after curing, or by other method approved by the overlay system manufacturer.

Obtain approval to open any course to traffic. Obtain approval of cleaning and surface preparation methods for initial courses that were opened to traffic before the final course was applied. Do not allow construction traffic on the final course until it has cured sufficiently to prevent damage by wheel loads. Minimum curing periods will be in accordance with the submitted curing time chart.

5.8. **Repair of Defects**. The Department will examine the completed work for defects. Immediately repair or take corrective action for delaminations, raveling, weathering, incomplete aggregate coverage, or other defects found during the Department's examination.

6. MEASUREMENT

Concrete overlay, latex-modified concrete overlay, and multi-layer polymer overlay will be measured by the square yard of surface overlaid using the dimensions shown on the plans. Overlay 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.

7. 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 Overlay," "Reinforced Concrete Overlay," and "Latex-Modified Concrete Overlay" of the specified depth or for "Multi-Layer Polymer Overlay."

Payment for “Concrete Overlay” or “Latex-Modified Concrete Overlay” is full compensation for cleaning surface, furnishing and placing grout; cleaning and restoration of reinforcing steel; furnishing and placing reinforcing steel; and furnishing, placing, finishing and curing the concrete overlay.

Payment for “Multi-Layer Polymer Concrete Overlay” is full compensation for: surface preparation; surface preparation testing; presence of overlay system manufacturer’s representative at initiation of the work and as requested; furnishing and applying crack sealant and multiple-layer polymer concrete overlay courses; repairing damaged or marred overlay surfaces; and all materials, labor, tools, equipment, and incidentals.

These prices are full compensation for materials, tools, equipment, labor, and incidentals.

Repair of deteriorated concrete below the level of scarification will be paid for in accordance with Item 429, “Concrete Structure Repair.”

Concrete removal and surface preparation beyond cleaning utilizing air, water, and abrasive blasting will be paid for in accordance with Item 483, “Concrete Bridge Deck Surfacing,” when overlaying existing bridge.

Item 440
Reinforcement for Concrete

1. DESCRIPTION

Furnish and place reinforcement of the type, size, and details shown on the plans.

2. MATERIALS

Use deformed steel bar reinforcement unless otherwise specified or allowed.

2.1. **Approved Mills**. Before furnishing steel, producing mills of reinforcing steel for the Department must be pre-approved in accordance with DMS-7320, "Qualification Procedure for Reinforcing Steel Producing Mills," by the Construction Division. The Department's MPL has a list of approved producing mills. Reinforcing steel obtained from unapproved sources will not be accepted.

Contact the Construction Division with the name and location of the producing mill for stainless reinforcing steel, low carbon/chromium reinforcing steel, or dual-coated reinforcing steel at least 4 weeks before ordering any material.

2.2. **Deformed Steel Bar Reinforcement**. Provide deformed reinforcing steel conforming to one of the following:

- ASTM A615, Grades 60, 75, or 80;
- ASTM A996, Type A, Grade 60;
- ASTM A996, Type R, Grade 60, permitted in concrete pavement only (Furnish ASTM A996, Type R bars as straight bars only and do not bend them. Bend tests are not required.); or
- ASTM A706, Grades 60 or 80.

Provide the grade of reinforcing steel shown on the plans. Provide Grade 60 if no grade is shown.

The nominal size, area, and weight of reinforcing steel bars this Item covers are shown in Table 1.

Table 1
Size, Area, and Weight of Reinforcing Steel Bars

Bar Size Number	Diameter (in.)	Area (sq. in.)	Weight per Foot (lbs.)
3	0.375	0.11	0.376
4	0.500	0.20	0.668
5	0.625	0.31	1.043
6	0.750	0.44	1.502
7	0.875	0.60	2.044
8	1.000	0.79	2.670
9	1.128	1.00	3.400
10	1.270	1.27	4.303
11	1.410	1.56	5.313
14	1.693	2.25	7.650
18	2.257	4.00	13.60

2.3. **Smooth Steel Bar Reinforcement**. Provide smooth bars for concrete pavement with a yield strength of at least 60 ksi and meeting ASTM A615. Provide steel conforming to ASTM A615 or meet the physical requirements of ASTM A36 for smooth bars that are larger than No. 3. Designate smooth bars by size number up to No. 4 and by diameter in inches above No. 4.

2.4. **Spiral Reinforcement**. Provide bars or wire for spiral reinforcement of the grade and minimum size or gauge shown on the plans.

Provide smooth or deformed wire conforming to ASTM A1064. Provide bars conforming to ASTM A615; ASTM A996, Type A; or ASTM A675, Grade 80, meeting dimensional requirements of ASTM A615.

2.5. **Weldable Reinforcing Steel**. Provide reinforcing steel conforming to ASTM A706 or with a maximum carbon equivalent (C.E.) of 0.55% if welding of reinforcing steel is required or desired. Provide a report showing the percentages of elements necessary to establish C.E. for reinforcing steel that does not meet ASTM A706, in order to be structurally welded. These requirements do not pertain to miscellaneous welds on reinforcing steel as defined in Section 448.4.2.1.1., "Miscellaneous Welding Applications."

Calculate C.E. using the following formula:

$$C.E. = \%C + \frac{\%Mn}{6} + \frac{\%Cu}{40} + \frac{\%Ni}{20} + \frac{\%Cr}{10} - \frac{\%Mo}{50} - \frac{\%V}{10}$$

Do not weld stainless reinforcing steel without permission from the Engineer. Provide stainless reinforcing steel suitable for welding, if required, and submit welding procedures and electrodes to the Engineer for approval.

2.6. **Welded Wire Reinforcement**. Provide welded wire reinforcement (WWR) conforming to ASTM A1064. Observe the relations shown in Table 2 among size number, diameter in inches, and area when ordering wire by size numbers, unless otherwise specified. Precede the size number for deformed wire with "D" and for smooth wire with "W."

Designate WWR as shown in the following example: 6 × 12 – W16 × W8 (indicating 6-in. longitudinal wire spacing and 12-in. transverse wire spacing with smooth No. 16 wire longitudinally and smooth No. 8 wire transversely).

Table 2
Wire Size Number, Diameter, and Area

Size Number (in.)	Diameter (in.)	Area (sq. in.)
31	0.628	0.310
30	0.618	0.300
28	0.597	0.280
26	0.575	0.260
24	0.553	0.240
22	0.529	0.220
20	0.505	0.200
18	0.479	0.180
16	0.451	0.160
14	0.422	0.140
12	0.391	0.120
10	0.357	0.100
8	0.319	0.080
7	0.299	0.070
6	0.276	0.060
5.5	0.265	0.055
5	0.252	0.050
4.5	0.239	0.045
4	0.226	0.040
3.5	0.211	0.035
2.9	0.192	0.035
2.5	0.178	0.025
2	0.160	0.020
1.4	0.134	0.014
1.2	0.124	0.012
0.5	0.080	0.005

Note—Size numbers (in.) are the nominal cross-sectional area of the wire in hundredths of a square inch. Fractional sizes between the sizes listed above are also available and acceptable for use.

2.7. **Epoxy Coating**. Provide epoxy coated reinforcing steel as shown on the plans. Before furnishing epoxy coated reinforcing steel, an epoxy applicator must be pre-approved in accordance with DMS-7330, "Qualification Procedure for Reinforcing Steel Epoxy Coating Applicators." The Department's MPL has a list of approved applicators.

Furnish coated reinforcing steel meeting the requirements in Table 3.

Table 3
Epoxy Coating Requirements for Reinforcing Steel

Material	Specification
Bar	ASTM A775 or A934
Wire or WWR	ASTM A884 Class A or B
Mechanical couplers	As shown on the plans
Hardware	As shown on the plans

Use epoxy coating material and coating repair material that complies with DMS-8130, "Epoxy Powder Coating for Reinforcing Steel." Patch no more than 1/4-in. total length in any foot at the applicator's plant.

Maintain identification of all reinforcing steel throughout the coating and fabrication process and until delivery to the project site.

Furnish 1 copy of a written certification verifying the coated reinforcing steel meets the requirements of this Item and 1 copy of the manufacturer's control tests.

2.8. **Mechanical Couplers**. Use couplers of the type specified in DMS-4510, "Mechanical Couplers for Reinforcing Steel," Article 4510.5.A, "General Requirements," when mechanical splices in reinforcing steel bars are shown on the plans.

Furnish only couplers pre-qualified in accordance with DMS-4510, "Mechanical Couplers for Reinforcing Steel." Ensure sleeve-wedge type couplers are not used on coated reinforcing. Sample and test couplers for use on individual projects in accordance with DMS-4510, "Mechanical Couplers for Reinforcing Steel." Furnish couplers only at locations shown on the plans.

Furnish couplers for stainless reinforcing steel with the same alloy designation as the reinforcing steel.

2.9. **Fibers**. Supply fibers conforming to DMS-4550 "Fibers for Concrete" at the minimum dosage listed in the Department's MPL, when allowed by the plans. Use non-metallic fibers when shown on the plans.

2.10. **Stainless Reinforcing Steel**. Provide deformed steel bars of the types listed in Table 4 and conforming to ASTM A955, Grade 60 or higher when stainless reinforcing steel is required on the plans.

Table 4
Acceptable Types of Deformed Stainless Steel Bar

UNS Designation	S31653	S31803	S24100	S32304
AISI Type	316LN	2205	XM-28	2304

2.11. **Low Carbon/Chromium Reinforcing Steel**. Provide deformed steel bars conforming to ASTM A1035, Grade 100 when low carbon/chromium reinforcing steel is required on the plans.

2.12. **Dual-Coated Reinforcing Steel**. Provide deformed bars conforming to ASTM A1055, Grade 60 or higher when dual-coated reinforcing steel is required on the plans.

2.13. **Glass Fiber Reinforced Polymer Bars (GFRP)**. Provide bars conforming to the AASHTO LRFD *Bridge Design Guide Specifications for GFRP-Reinforced Concrete Bridge Decks and Traffic Railings*, Section 4, "Material Specifications" when GFRP bars are required on the plans. Provide sample certification demonstrating the GFRP bar supplier has produced bar that meets the Material Specifications 2 mo. before fabrication. Furnish certification upon shipment that the GFRP bar supplied meets the Material Specifications.

3. CONSTRUCTION

3.1. **Bending**. Fabricate reinforcing steel bars as prescribed in the CRSI *Manual of Standard Practice* to the shapes and dimensions shown on the plans. Fabricate in the shop if possible. Field-fabricate, if permitted, using a method approved by the Engineer. Replace improperly fabricated, damaged, or broken bars at no additional expense to the Department. Repair damaged or broken bars embedded in a previous concrete placement using a method approved by the Engineer.

Unless otherwise shown on the plans, the inside diameter of bar bends, in terms of the nominal bar diameter (d), must be as shown in Table 5.

Table 5
Minimum Inside Diameter of Bar Bends

Bend	Bar Size Number (in.)	Pin Diameter
Bends of 90° and greater in stirrups, ties, and other secondary bars that enclose another bar in the bend	3, 4, 5	4d
	6, 7, 8	6d
Bends in main bars and in secondary bars not covered above	3 through 8	6d
	9, 10, 11	8d
	14, 18	10d

Bend-test representative specimens as described for smaller bars in the applicable ASTM specification where bending No. 14 or No. 18 Grade 60 bars is required. Make the required 90° bend around a pin with a diameter of 10 times the nominal diameter of the bar.

Bend stainless reinforcing steel in accordance with ASTM A955.

3.2. **Tolerances**. Fabrication tolerances for bars are shown in Figure 1.

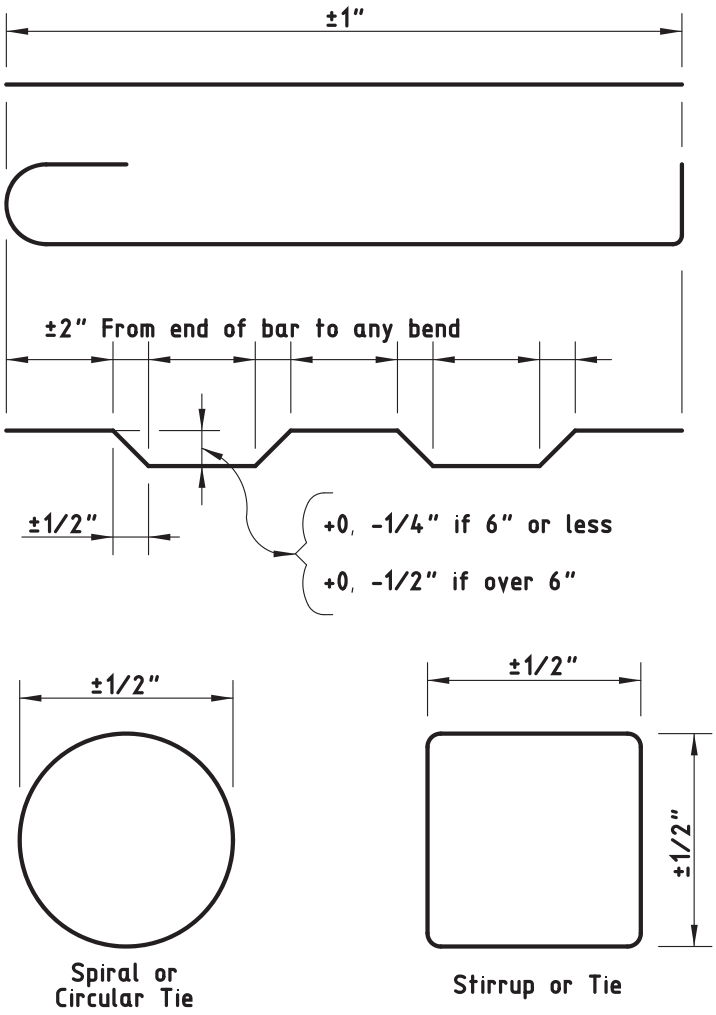

Figure 1
Fabrication Tolerances for Bars

3.3. **Storage**. Store reinforcement above the ground on platforms, skids, or other supports, and protect it from damage and deterioration. Ensure reinforcement is free from dirt, paint, grease, oil, and other foreign materials when it is placed in the work. Use reinforcement free from defects such as cracks and delaminations. Rust, surface seams, surface irregularities, or mill scale will not be cause for rejection if the minimum cross-sectional area of a hand wire-brushed specimen meets the requirements for the size of steel specified.

Do not allow stainless reinforcing steel to be in direct contact with uncoated reinforcing steel, nor with galvanized reinforcing steel. This does not apply to stainless steel wires and ties. Store stainless reinforcing steel separately, off the ground on wooden supports.

3.4. **Splices**. Lap-splice, weld-splice, or mechanically splice bars as shown on the plans. Additional splices not shown on the plans will require approval. Splices not shown on the plans will be permitted in slabs no more than 15 in. in thickness, columns, walls, and parapets.

- Do not splice bars less than 30 ft. in plan length unless otherwise approved. For bars exceeding 30 ft. in plan length, the distance center-to-center of splices must be at least 30 ft. minus 1 splice length, with no more than 1 individual bar length less than 10 ft. Make lap splices not shown on the plans, but otherwise

permitted, in accordance with Table 6. Maintain the specified concrete cover and spacing at splices, and place the lap-spliced bars in contact, securely tied together.

Table 6
Minimum Lap Requirements for Steel Bar Sizes through No. 11

Bar Size Number (in.)	Uncoated Lap Length	Coated Lap Length
3	1 ft. 4 in.	2 ft. 0 in.
4	1 ft. 9 in.	2 ft. 8 in.
5	2 ft. 2 in.	3 ft. 3 in.
6	2 ft. 7 in.	3 ft. 11 in.
7	3 ft. 5 in.	5 ft. 2 in.
8	4 ft. 6 in.	6 ft. 9 in.
9	5 ft. 8 in.	8 ft. 6 in.
10	7 ft. 3 in.	10 ft. 11 in.
11	8 ft. 11 in.	13 ft. 5 in.

- Do not lap No. 14 or No. 18 bars.
- Lap spiral steel at least 1 turn.
- Splice WWR using a lap length that includes the overlap of at least 2 cross wires plus 2 in. on each sheet or roll. Splices using bars that develop equivalent strength and are lapped in accordance with Table 6 are permitted.
- Lap the existing longitudinal bars with the new bars as shown in Table 6 for box culvert extensions with less than 1 ft. of fill. Lap at least 1 ft. 0 in. for extensions with more than 1 ft. of fill.
- Ensure welded splices conform to the requirements of the plans and of Item 448, “Structural Field Welding.” Field-prepare ends of reinforcing bars if they will be butt-welded. Delivered bars must be long enough to permit weld preparation.
- Install mechanical coupling devices in accordance with the manufacturer’s recommendations at locations shown on the plans. Protect threaded male or female connections, and ensure the threaded connections are clean when making the connection. Do not repair damaged threads.
- Mechanical coupler alternate equivalent strength arrangements, to be accomplished by substituting larger bar sizes or more bars, will be considered if approved in writing before fabrication of the systems.

3.5. **Placing**. Place reinforcement as near as possible to the position shown on the plans. Do not vary bars from plan placement by more than 1/12 of the spacing between bars in the plane of the bar parallel to the nearest surface of concrete. Do not vary bars from plan placement by more than 1/4 in in the plane of the bar perpendicular to the nearest surface of concrete. Provide a minimum 1-in. clear cover of concrete to the nearest surface of bar unless otherwise shown on the plans.

For bridge slabs, the clear cover tolerance for the top mat of reinforcement is −0, +1/2 in.

Locate the reinforcement accurately in the forms, and hold it firmly in place before and during concrete placement by means of bar supports that are adequate in strength and number to prevent displacement and keep the reinforcement at the proper distance from the forms. Provide bar supports in accordance with the CRSI *Manual of Standard Practice*. Use Class 1 supports, approved plastic bar supports, precast mortar, or concrete blocks when supports are in contact with removable or stay-in-place forms. Use Class 3 supports in slab overlays on concrete panels or on existing concrete slabs. Bar supports in contact with soil or subgrade must be approved.

Use Class 1A supports with epoxy coated reinforcing steel. Provide epoxy or plastic coated tie wires and clips for use with epoxy coated reinforcing steel.

Use mortar or concrete with a minimum compressive strength of 5,000 psi for precast bar supports. Provide a suitable tie wire in each block for anchoring to the bar.

Place individual bar supports in rows at 4-ft. maximum spacing in each direction. Place continuous type bar supports at 4-ft. maximum spacing. Use continuous bar supports with permanent metal deck forms.

The exposure of the ends of longitudinals, stirrups, and spacers used to position the reinforcement in concrete pipe and storm drains is not cause for rejection.

Tie reinforcement for bridge slabs and top slabs of direct traffic culverts at all intersections, except tie only alternate intersections where spacing is less than 1 ft. in each direction. Tie the bars at enough intersections to provide a rigid cage of reinforcement for reinforcement cages for other structural members. Fasten mats of WWR securely at the ends and edges.

Clean mortar, mud, dirt, debris, oil, and other foreign material from the reinforcement before concrete placement. Do not place concrete until authorized.

Stop placement until corrective measures are taken if reinforcement is not adequately supported or tied to resist settlement, reinforcement is floating upward, truss bars are overturning, or movement is detected in any direction during concrete placement.

3.6. **Handling, Placing, and Repairing Epoxy Coated Reinforcing Steel**.

3.6.1. **Handling**. Provide systems for handling coated reinforcing steel with padded contact areas. Pad bundling bands or use suitable banding to prevent damage to the coating. Lift bundles of coated reinforcement with a strongback, spreader bar, multiple supports, or a platform bridge. Transport the bundled reinforcement carefully, and store it on protective cribbing. Do not drop or drag the coated reinforcement.

3.6.2. **Placing**. Do not flame-cut coated reinforcement. Saw or shear-cut only when approved. Coat cut ends as specified in Section 440.3.6.3., “Repairing Coating.”

Do not weld or mechanically couple coated reinforcing steel except where specifically shown on the plans. Remove the epoxy coating at least 6 in. beyond the weld limits before welding and 2 in. beyond the limits of the coupler before assembly. Clean the steel of oil, grease, moisture, dirt, welding contamination (slag or acid residue), and rust to a near-white finish after welding or coupling. Check the existing epoxy for damage. Remove any damaged or loose epoxy back to sound epoxy coating.

Coat the splice area after cleaning with epoxy repair material to a thickness of 7 to 17 mils after curing. Apply a second application of repair material to the bar and coupler interface to ensure complete sealing of the joint.

3.6.3. **Repairing Coating**. Use material that complies with the requirements of this Item and ASTM D3963 for repairing of the coating. Make repairs in accordance with procedures recommended by the manufacturer of the epoxy coating powder. Apply at least the same coating thickness as required for the original coating for areas to be patched. Repair all visible damage to the coating.

Repair sawed and sheared ends, cuts, breaks, and other damage promptly before additional oxidation occurs. Clean areas to be repaired to ensure they are free from surface contaminants. Make repairs in the shop or field as required.

3.7. **Handling and Placing Stainless Reinforcing Steel**. Handle, cut, and place stainless reinforcing steel bar using tools that are not used on carbon steel. Do not use carbon steel tools, chains, slings, etc. when handling stainless steel. Use only nylon or polypropylene slings. Cut stainless steel reinforcing using shears, saws, abrasive cutoff wheels, or torches. Remove any thermal oxidation using pickling paste. Do not field bend stainless steel reinforcing without approval.

Use 16 gauge fully annealed stainless steel tie wire conforming to the material properties listed in Section 440.2.10., “Stainless Reinforcing Steel.” Support all stainless reinforcing steel on solid plastic, stainless steel, or epoxy coated steel chairs. Do not use uncoated carbon steel chairs in contact with stainless reinforcing steel.

3.8. **Bending, Handling, Repairing, and Placing GFRP Bars**. Fabricate, handle, repair, and place GFRP bars in accordance with the AASHTO LRFD Bridge Design Guide Specifications for GFRP-Reinforced Concrete Bridge Decks and Traffic Railings, Section 5, Construction Specifications.

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 considered subsidiary to pertinent Items.

Item 446
Field Cleaning and Painting Steel

1. DESCRIPTION

Prepare steel surfaces for painting and apply paint.

2. MATERIALS

Provide the paint system (surface preparation, primer, intermediate, and appearance coats as required) shown on the plans. Provide System II if no system specified. Provide a concrete gray appearance coat (Federal Standard 595C, color 35630,) unless otherwise shown on the plans. Use differing colors for each individual coat with enough contrast between colors to distinguish the various steps in the painting process, including differing the color of the stripe coat relative to the primer and intermediate coat.

2.1. **Paint Systems**. Standard paint systems for painting new and existing steel include the following:

2.1.1. **System I-A (Overcoating, One Coat)**. Provide an overcoating system in accordance with DMS-8105, "Paint, One Coat Overcoat," and the manufacturer's specifications.

2.1.2. **System I-B (Overcoating, High Corrosion Environment)**. Provide paint in accordance with DMS-8101, "Structural Steel Paints—Performance." Provide a penetrating sealer, intermediate prime coat on bare steel areas, and an appearance coat in accordance with manufacturer's specifications.

2.1.3. **System II**. Provide #810 Prime Coat meeting DMS-8100, "Structural Steel Paints—Formula," and acrylic latex appearance coat meeting DMS-8101, "Structural Steel Paints—Performance."

2.1.4. **System III-A**. Provide paint in accordance with DMS-8101, "Structural Steel Paints—Performance." Provide organic zinc (OZ) prime coat, epoxy intermediate stripe coat, epoxy intermediate full coat and urethane appearance coat.

2.1.5. **System III-B**. Provide paint in accordance with DMS-8101, "Structural Steel Paints—Performance." Provide inorganic zinc (IOZ) prime coat, epoxy intermediate, and urethane appearance coat. Provide epoxy zinc prime coat, as recommended by the IOZ manufacturer, for touchup of IOZ.

2.1.6. **System IV**. Provide paint in accordance with DMS-8101, "Structural Steel Paints—Performance." Provide IOZ prime coat and acrylic latex appearance coat. Provide epoxy zinc prime coat, as recommended by the IOZ manufacturer, for touchup of IOZ.

2.2. **Paint Inside Tub Girders and Closed Boxes**. In accordance with Item 441, "Steel Structures."

2.3. **Paint over Galvanizing**. In accordance with Item 445, "Galvanizing."

2.4. **Special Protection System**. Provide the type of paint system shown on the plans or in special provisions to this Item. Special Protection System paints must have completed NTPEP Structural Steel Coatings (SSC) testing regimen as a complete system, with full data available through NTPEP unless specified otherwise.

3. EQUIPMENT

Ensure spray equipment:

- has adequate capacity and sufficient gauges, filters, agitators, regulators, and moisture separators to ensure delivery of clean dry air at the proper pressure and volume;
- is adequate for the type of paint being used;
- has spray heads that provide a smooth, uniform coat of paint;
- will remove moisture from air stream in contact with the paint; and
- has no dried coatings, solvents, or other foreign matter on surfaces that paint is likely to contact.

Maintain all equipment and accessories in good working order.

Keep paint pots no more than 20 ft. above or below the level of spray application of paint during painting operations. Do not allow fluid hoses to sag more than 10 ft. below the level of the bottom of the paint pot or actual spraying operations, whichever is the lowest point. Keep hoses serviceable with no cracks or deterioration. Equip paint pots (or other containers from which the paint is dispensed) with agitators that operate whenever paint is in the pot.

3.1. **Airless Spray Equipment**. Use regulator and air or fluid pressure gauges. Use fluid hoses with at least 1/4-in. inside diameter (I.D.) and a maximum length of 75 ft.

3.2. **Conventional Spray Equipment**. Use independent fluid pressure and atomization pressure regulators and gauges. Use fluid and air hoses with at least 1/2-in. I.D. and a maximum length of 75 ft.

4. CONSTRUCTION

4.1. **Qualification**. Certification of the cleaning and painting contractor, subcontractor, or fabricator is required as follows:

Submit to the Engineer documentation verifying SSPC QP 1 certification for work requiring the removal or application of coatings. Additionally, submit to the Engineer documentation verifying SSPC QP 2 Cat A certification when work requires removal of coatings containing hazardous materials. Maintain certifications throughout the project. No work may be performed without current and active certifications unless otherwise shown on the plans. The Engineer may waive QP 1 certification for minor, touch-up repair work and coating steel members repaired in accordance with Item 784, “Steel Member Repair.”

The Engineer may waive certification requirements, when stated on the plans, for the purpose of qualification in the SSPC QP program if the SSPC has accepted the project as a qualification project as part of the process for obtaining SSPC QP1 or QP2 Cat A certification. Submit SSPC QP applications and proof of acceptance before beginning work or provide SSPC QP 7 certification when required on the plans.

Inform the Engineer within 1 business day of all scheduled or unannounced inspections or audits by SSPC, OSHA, EPA, TCEQ, or other agencies or organizations. Furnish the Engineer a complete copy of all inspection and audit reports and any SSPC DAC actions within 7 days of receipt.

4.2. **Responsibility for Hazards**. Comply with Section 6.10., “Hazardous Materials.” Handle all paints and cleaning products in accordance with the information provided by the manufacturer and all applicable federal and state regulations.

4.3. **Access**. Provide safe access to all parts of the work for proper inspection. Do not place rigging, scaffolds, etc., in contact with previously painted surfaces until the previously applied coating has fully cured. Protect previously painted and cured surfaces with an approved padding to minimize damage when rigging, scaffolds, etc., will be placed on or hung from those surfaces. Avoid and minimize coating damage to the extent possible. Repair all coating damaged as a result of rigging or scaffolding as directed.

Remove tree limbs, bushes, grass, and other items that will interfere with the cleaning and painting operations as directed. Remove vertical clearance signs, and erect and maintain temporary ground-mounted signs matching the content and letter size on the existing sign unless otherwise directed. Re-attach permanent clearance signs as directed.

4.4. **Steel to be Painted**. Clean and paint all structural steel except weathering steel that is to remain unpainted, unless otherwise shown on the plans. Structural steel includes all main members, bearing apparatus, diaphragms, floor beams, rivets, bolts, lateral bracing, etc., where applicable. Paint the rolling faces of rockers and base plates, all surfaces of bearing plates, and all surfaces of iron or steel castings, whether or not the surfaces are milled unless otherwise shown on the plans or exempted in this Item. Perform the initial cleaning and application of required prime and intermediate coatings on new steel before shipment of the steel to the jobsite unless otherwise provided in the Contract or approved in writing.

4.5. **Special Protection System**. Apply paint as shown on the plans.

4.6. **Cleaning and Painting New Steel**. Clean and prime new steel in accordance with Item 441, “Steel Structures,” before erection or installation of repair pieces. Clean and paint unpainted areas of newly erected steel, including bolts, nuts, washers, and areas where the shop-applied paint has been damaged or fails to meet specification requirements, in accordance with the method required under the paint system specified and Section 446.4.7.3.1., “General Preparation.” Water blast exposed surfaces of all newly erected steel. Provide Tool Cleaning surface preparation to all repair areas. Prepare all unpainted areas with Abrasive Blast Cleaning. Repair primer coat and apply remaining coats after erection and maintenance work is complete. Prevent paint and overspray from coming in contact with passing traffic, private and public property, and areas of the bridge not designated to be painted.

4.7. **Cleaning and Painting Existing Steel**.

4.7.1. **Hold Points**. No work may proceed beyond the listed hold point until the Engineer has reviewed and given provisional approval. Provide the following hold points at a minimum:

- at containment completion,
- following any surface preparation,
- immediately before each coating application,
- after coating application,
- after each coat has cured, and
- after preparation of areas for repair.

4.7.2. **Containment**. Submit a plan that details the procedures and type and size of equipment proposed to keep public property, private property, and the environment from being adversely affected by the cleaning and painting operations. Approval of the plan is required before cleaning and painting operations begin. Containment is not required for painting newly erected, shop primed steel other than to comply with Section 446.4.6., “Cleaning and Painting New Steel.”

When required on the plans, submit a containment plan and engineering analysis showing the loads, including wind loads, added to the existing structure by the containment system and waste materials. Verify the forces and stresses induced in the members from these loads do not result in overstress of the members. Have a licensed professional engineer sign, seal, and date the submittal.

Provide containment during all cleaning and painting operations of existing steel structures. Obtain approval of the constructed containment system before beginning cleaning and painting.

Unless otherwise shown on the plans, construct and maintain a structure meeting the following minimum requirements:

- SSPC Guide 6, Class 1A, Level 1 Emissions;
- ability to withstand winds up to 30 mph;
- enclosure of all sides of area with air-impenetrable walls;
- illumination meeting SSPC Guide 12;
- rigid, watertight floor formed from minimum 20 gauge steel;
- overlapping seams and entryways; and
- exhaust air filtration system capable of creating negative pressure inside the enclosure causing the sides of the containment to have a concave appearance and demonstrating minimum 100 ft. per minute cross draft air flow and minimum 50 ft. per minute downdraft air flow in all areas within the containment.

In place of a full containment structure, a modified containment system may be proposed for the following situations:

- when using abrasive blasting equipment equipped with negative pressure able to contain all blast refuse. Demonstrate, for approval, the equipment's ability to contain all blast refuse.
- when using hand tools for spot cleaning only, provide a system that will contain all removed paint, rust, and other debris. Place an airtight membrane below the member being cleaned to collect all falling debris.
- when using power hand tools for spot cleaning only that are equipped with high-efficiency particulate air (HEPA) filter vacuums that will capture all removed paint, rust, and other debris. Otherwise, provide an airtight membrane below the member being cleaned to collect all falling debris.

Provide a system meeting SSPC Guide 6, Class 1W, when using water blasting.

Store, characterize, and dispose of all recovered debris in accordance with 30 TAC 335, "Industrial Solid Waste and Municipal Hazardous Waste." Alternatively, Universal Waste rules may be used. Discharge liquids in accordance with the TCEQ Texas Pollution Discharge Elimination Program (30 TAC 305, "Effluent Guidelines and Standards for TPDES Permits") and Texas Surface Water Quality Standards (30 TAC 307). Alternatively, liquids may be captured, stored, and characterized for disposal at an authorized facility in accordance with 30 TAC 315, "Pretreatment Regulation for Existing and New Sources of Pollution," or 30 TAC 335, "Industrial Solid Waste and Municipal Hazardous Waste."

Use a skimmer when cleaning and painting over bodies of water. Remove any blast or paint material the skimmer collects the day the release occurs. Correct the containment problem that allowed the release before continuing work.

Ensure air is clear of dust and remove all blast refuse from cleaned members before the inspector enters the containment to inspect the cleaned surfaces. Remove all blast refuse from the containment before ending work for the day.

4.7.3. **Preparation of Surfaces**. Prepare surfaces before applying paint.

4.7.3.1. **General Preparation**. Clean far enough into any shop-applied paint to ensure removal of all contaminants. Feather edges of sound paint around cleaned areas.

Ensure all surfaces to be painted are completely free of oil, grease, moisture, dirt, sand, overspray, welding contamination (slag or acid residue); loose or flaking mill scale, rust, or paint; weld spatter; and any other conditions that will prevent the paint from forming a continuous, uniform, tightly adhering film. Remove all hackles, splinters weld spatter, sharp edges, fins, slag, or other irregularities which may interfere with proper paint adhesion to the steel. Remove all steel splinters (hackles) raised or evident during cleaning. Reblast areas from which hackles are removed when abrasive blast cleaning is required.

Before other cleaning operations, remove grease-like contaminants with clean petroleum solvents or other approved methods. Contain solvents and removed material as approved. Dispose of properly or reuse solvents as approved. This requirement applies to all coats.

When abrasive blast cleaning is required, blast all flame-cut edges to produce a visible anchor pattern over the entire flame-cut surface.

Completely remove, as directed, the protective coating on machined surfaces and pins.

Do not damage adjacent materials such as concrete during surface preparation or painting.

Feather all sound, tightly adhered coating edges surrounding cleaned or repaired areas a minimum of 1 in. and ensure a smooth, blended transition.

Round all corners and edges to a 1/16-in. radius. Reblast as needed. Remove pack rust to depth of at least 0.5 in.

4.7.3.2. **Classes of Cleaning**. The requirements of Section 446.4.7.3.1., "General Preparation," apply whether or not a class of cleaning is specified. Use an approved abrasive for abrasive blasting. Do not use steel shot. Use an abrasive recycling system with an approved recyclable abrasive when abrasive blast cleaning is used to remove existing paint containing lead or chromium. Abrasive will be considered recyclable if it is separated from the dust and paint debris before being reused. All abrasives must meet SSPC-AB1, AB2, or AB3 as appropriate.

All paint systems require water blasting to remove contaminants before any other surface preparation. Both System I-A and I-B require tool cleaning for defective areas of disbonded coating or rust. All other paint systems require abrasive blast cleaning unless otherwise shown on the plans.

4.7.3.2.1. **Abrasive Blast Cleaning**. Meet the surface preparation requirements of SSPC-SP 10 unless otherwise shown on the plans. Ensure a minimum profile of 1.5 mils. Do not add depth to existing profile when the surface profile exceeds 4.0 mils. Measure surface profile in accordance with ASTM D4417, Method C, "Standard Test Methods for Field Measurement of Surface Profile of Blast Cleaned Steel." Containment mounting points and other repair areas under 1 sq. ft. may be tool-cleaned to SSPC SP-11 with at least a minimum 2 mil profile when approved by the Engineer.

4.7.3.2.2. **Tool Cleaning**. Meet the requirements of SSPC-SP2 or SP3 unless otherwise shown on the plans. Probe the perimeter of peeled areas of paint with a putty knife to ensure remaining paint is tightly adhered.

4.7.3.2.3. **Water Blasting**. Meet the requirements of SSPC-SP WJ-4. Tight mill scale and tightly adhered rust and paint are permitted. Probe the perimeter of peeled areas of paint with a putty knife to ensure remaining paint is tightly adhered.

4.7.3.3. **Tape Test**. Perform the tape test, as necessary to determine cleanliness, on any surface before painting as follows:

- Press a strip of filament tape onto the surface by rubbing with moderate thumb pressure 4 times, leaving approximately 2 in. of one end of the tape free from the surface.
- Grasp the free end and remove the tape from the surface with a sharp pull.

The surface will be considered to be contaminated and not adequately cleaned if visible particles cling to the tape.

4.7.4. **Painting**.

4.7.4.1. **Paint Condition**. Thoroughly mix and strain paints to be applied. Mix by mechanical methods. Provide continuous mechanical agitation during painting operations to prevent settling. Ensure the paint is a completely homogeneous mixture free of lumps, skins, and agglomerates and contains all pigments, vehicle

solids, and thinners required in the original formulation. Keep paint containers tightly covered and protected from weather when not in use.

4.7.4.2. **Thinning**. Adjust paint to the correct application consistency by using suitable thinners or by using properly applied heat up to 150°F. Using heat to thin paints may decrease their useful pot life.

4.7.4.3. **Paint System Requirements**. Ensure all coatings in the paint system, including shop-applied coats, are from the same manufacturer.

4.7.4.4. **Stripe Coat**. All stripe coat, when specified, will be unthinned and worked in by brush to achieve a contiguous film over all edges, corners, bolts, nuts, threads, rivets, and weld seams, extending at least 1 in. onto adjacent steel.

4.7.4.5. **Paint Systems**.

4.7.4.5.1. **System I-A (Overcoating, One Coat)**. Apply at least 4.0 mils dry film thickness (DFT) maintenance overcoat to all surfaces to be painted.

4.7.4.5.2. **System I-B (Overcoating, High Corrosion Environment)**.

- **Penetrating Sealer**. Apply 0.5–1.0 mil DFT of penetrating sealer to all surfaces to be painted.
- **Prime Coat**. Apply 4.0–8.0 mils DFT of primer to areas that have received tool cleaning and to other areas where there is no existing primer.
- **Appearance Coat**. Apply 2.0–6.0 mils DFT of appearance coat.

4.7.4.5.3. **System II**.

- **Prime Coat**. Apply 3.5–10.0 mils DFT of primer in at least 2 coats.
- **Appearance Coat**. Apply 2.0–5.0 mils DFT of appearance coat.

4.7.4.5.4. **System III-A**.

- **Prime Coat**. Apply at least 3.5 mils DFT of epoxy zinc primer.
- **Stripe Coat**. Apply stripe coat of epoxy intermediate coating.
- **Intermediate Coat**. Apply at least 2.0 mils DFT of epoxy intermediate coating.
- **Appearance Coat**. Apply at least 2.0 mils DFT of appearance coating.

4.7.4.5.5. **System III-B**.

- **Prime Coat**. Apply at least 3.0 mils DFT of inorganic zinc primer to new steel in accordance with Item 441, “Steel Structures.” Spot-clean all damaged and unpainted areas in accordance with Section 446.4.6., “Cleaning and Painting New Steel.” Apply at least 3.0 mils DFT of epoxy zinc primer to the spot cleaned areas.
- **Stripe Coat**. Apply stripe coat of epoxy intermediate coating.
- **Intermediate Coat**. Apply at least 2.0 mils DFT of epoxy intermediate coating.
- **Appearance Coat**. Apply at least 2.0 mils DFT of appearance coat.

4.7.4.5.6. **System IV**.

- **Prime Coat**. Apply at least 3.0 mils DFT of inorganic zinc primer to new steel in accordance with Item 441, “Steel Structures.” Spot-clean all damaged and unpainted areas in accordance with Section 446.4.6., “Cleaning and Painting New Steel.” Apply at least 3.0 mils DFT of epoxy zinc primer to the spot cleaned areas.
- **Appearance Coat**. Apply at least 2.0 mils DFT of appearance coat.

4.7.4.5.7. **Special Protection System**. Apply paint as shown on the plans.

4.7.4.6. **Temperature**. Do not apply #810 Prime Coat when the steel or air temperature is below 50°F or when the steel or air temperature is expected to drop below 50°F within 2 hr. after application. Follow product data sheets for temperature requirements for all other paints.

4.7.4.7. **Application**. Clean steel surfaces or surfaces of previously applied coats of paint immediately before painting by blowing with clean compressed air, brushing, or both to remove traces of dust or other foreign particles. Wash the surfaces of previously applied coatings either with clean, fresh water or with a mild detergent and water mixture followed by a complete and thorough rinse with clean, fresh water when directed.

Do not apply paint to any surface with discernible moisture. Do not apply paint to any surface when steel is within 5°F of the dewpoint. Do not apply any paint when impending weather conditions might result in injury to fresh paint.

Provide environmental controls such as dehumidification, heaters, or additional containment measures as needed to control and maintain favorable atmospheric conditions in all areas of the containment. Provide environmental controls at no additional cost to the Department.

Apply each coat of paint to clean, dry, firm surfaces complying with all specification requirements. Ensure surfaces to be painted are free of all forms of contamination. Ensure each coat fully cures to form a smooth, continuous, tightly adhering film of uniform thickness and appearance, free of sags, runs, pinholes, holidays, overspray, or other defects before applying the next coat. Apply all coats by spray, except brush-applied stripe coats. Obtain Engineer approval for alternative methods of application to paint inaccessible areas.

Repair all runs, sags, and other defects in each coat of paint before application of subsequent coats.

Measure the dry film thickness of coatings in accordance with Tex-728-I.

If, in the opinion of the Engineer, there is an objectionable amount of dust in the atmosphere, discontinue painting or take necessary precautions to prevent dust and dirt from coming in contact with freshly painted surfaces or with surfaces before the paint is applied.

Provide full coverage of the steel with the concrete surface when painting steel that is in contact with concrete. Do not extend the paint more than 4 in. onto the concrete surfaces or as directed. Ensure when painting is complete the only visible paint on concrete surfaces is the finish coat. Remove excessive or objectionable paint on concrete surfaces in an approved manner.

Cure the primer, when System II is specified, in accordance with Table 1 before applying appearance coat.

Table 1
System II Primer Cure Times

Temperature	Days Cure, Min
77°F and above	2
65–77°F	3
55–65°F	4
40–55°F	5

Clean coated surfaces by an approved method that does not damage the paint to remove all dirt, grease, concrete, overspray, and any other substance that may impair adhesion before the application of the next coat.

Provide an even and uniform appearance throughout the painted portion of the structure.

4.7.4.8. **Workmanship**. Perform all painting with skilled painters who can adjust equipment and application techniques as dictated by the type of paint, weather conditions, environment, and size and shape of the surface being painted. Painters who, in the opinion of the Engineer, do not adjust equipment to apply coatings in a uniform, full wet coat free of runs, sags, holidays, and overspray will not be considered skilled painters.

Apply sprayed coatings essentially 90° to the surface and between 10 and 18 in. from the surface as necessary to apply a full wet coat of paint free of overspray, runs, sags, and holidays. Any spray painter who does not consistently spray in this manner or extends the spraying stroke so paint is applied to the surface at an angle of less than 80° will not be allowed to spray paint. Brush application for touchup is acceptable as long as the paint is mixed in the appropriate proportions by weight and is agitated continuously during the painting operation.

4.7.5. **Handling and Shipping**. Pad the blocks, chains, slings, braces, clamps, etc., used for handling, moving, storing, and shipping painted members so the paint will not be damaged.

4.8. **Paint Improperly Applied**. To uncover evidence of improperly applied paint, the Engineer may at any time during construction explore underneath the surface of any paint coats already applied. Repair these areas of investigation at no additional expense to the Department. Whenever unsatisfactory conditions are found, the Engineer may require remedial measures.

Repair or completely remove and replace all paint that has been applied improperly, has been applied to improperly cleaned surfaces, fails to dry and harden properly, fails to adhere tightly to underlying metal or other paint film, or does not have a normal, workmanlike appearance in conformance with this Item. When the final field coat does not have a uniform color and appearance throughout the structure, correct it by the use of whatever additional coats or other corrective measures are required. Remove freshly applied paint that has not yet set with the use of suitable solvents. Remove dried paint films with blast cleaning, scraping, or flame torches, as approved.

4.9. **Storage and Disposal**. Collect all waste generated by cleaning and painting operations as necessary to prevent release into the environment. At a minimum, collect all waste before leaving the jobsite each day. Handle and store the waste as if it was hazardous or Universal Waste until classification is made. Follow the requirements of 30 TAC 335 for on-site handling of the waste. Store waste collected in containers that comply with 49 CFR Part 178. Seal containers containing waste each day before leaving the jobsite.

Test a representative sample of waste using EPA Test Method 1311, “Toxicity Characteristic Leaching Procedure” (TCLP), to determine existing metal and organic content. Handle and dispose of non-hazardous waste as a “Special Waste” as defined in 30 TAC 330.2 or as directed. Provide documentation showing disposal of the waste was done in a suitable landfill holding permits to handle this type of material. Dispose of hazardous waste in compliance with applicable waste rules and regulations. Transport hazardous waste using a permitted transporter and dispose of in an authorized hazardous waste facility.

When the plans specify the existing coating to be removed contains hazardous materials and steel grit is used as the abrasive, the waste generated is classified as hazardous or Universal Waste regardless of the results of the TCLP. For manifesting purposes, the Department is considered the waste generator for paint removal wastes generated from structures owned or controlled by the State. Dispose of this waste in compliance with applicable waste rules and regulations as specified above and by the Contract.

Provide copies of all test reports and transportation manifests to the Engineer before shipping waste. Provide signed original manifests to the Engineer verifying all steps of the handling and disposal process were correctly handled.

4.10. **Miscellaneous**. Notify the Engineer of any condition that may require the repair or replacement of any portion of the bridge.

Stencil on the exterior face of the outside beam the control, section, and structure number upon completion of the painting operations for each structure as directed. Stencil on the interior face of the outside beam the completion date of the painting operation. Do this work at each end of the structure where painting is specified.

5. MEASUREMENT

When this Item is specified on the plans to be a pay item, this Item will be measured by the lump sum or by each structure, structure unit, or group of structures as shown on the plans.

6. PAYMENT

When this Item 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 price bid for “Cleaning and Painting Existing Structures,” “Cleaning and Painting Existing Railing,” or “Cleaning and Painting Existing Piling” for the system specified and, when paid by each, for the structure description by reference number. “Cleaning and Painting Existing Structures” includes painting of railing and piling unless otherwise shown on the plans. This price is full compensation for paint; cleaning, spot painting, and painting; removal of vegetative obstructions; containment systems; traffic protection and scaffolding; disposal of waste; and materials, equipment, labor, tools, and incidentals.

When the Item is not specified as a pay item, the work performed and materials furnished in accordance with this Item will not be measured or paid for directly but will be subsidiary to pertinent Items.

Item 450
Railing

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.

2. MATERIALS

Use materials that conform to requirements of the following Items.

- Item 421, “Hydraulic Cement Concrete,”
- Item 440, “Reinforcement for Concrete,”
- Item 441, “Steel Structures,”
- Item 442, “Metal for Structures,”
- Item 445, “Galvanizing,” and
- Item 540, “Metal Beam Guard Fence.”

Provide an approved Type III, Class C epoxy or an epoxy of the type and class stated on the plans where epoxy anchors are allowed or required for installing drilled and epoxied rail anchorage reinforcement or rail anchor bolts in accordance with DMS-6100, “Epoxies and Adhesives.” Use other materials if shown on the plans. Provide only dual cartridge epoxy systems mixed with a static mixing nozzle supplied by the epoxy adhesive manufacturer and dispensed with a tool supplied by the epoxy adhesive manufacturer. Do not use bulk epoxies. Drill and install anchorage reinforcement or anchor bolts to the embedment depth shown on the plans or the depth the manufacturer recommends, whichever is deeper. No additional payment will be made for providing embedment deeper than shown on the plans. Select an embedment depth capable of developing the yield strength of the steel anchor based on the product literature for the epoxy and steel anchor being used if no resistance or embedment depth is specified on the plans. Use 60 ksi as the yield strength for reinforcing steel.

3. CONSTRUCTION

Construct railing in accordance with details, alignment, and grade designated on the plans. Do not place railing until falsework or formwork, if any, for the span has been released unless otherwise directed. Adhere to the schedule restrictions for Placing Bridge Rails and Opening to Construction Traffic in Item 422, “Concrete Superstructures.” Notify the Engineer after completion of the following steps and obtain approval of work before proceeding to the next step: placing rail reinforcement and pre-pour clear cover checks.

Ensure expansion joints in the railing will function properly before placing concrete.

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

Install epoxy adhesive anchorages in accordance with the manufacturer’s instructions including hole size, drilling equipment and method, hole cleaning equipment and method, mixing and dispensing epoxy, and anchor insertion. Do not alter the manufacturer’s mixing nozzle or dispenser. Anchorage bars or bolts must be clean and free of grease, oil, or any other foreign material. Demonstrate hole cleaning method to the Engineer for approval and continue the approved process for all anchorage locations. Do not weld to an anchor bar or anchor bolt that is anchored with epoxy adhesive. Do not expose rail to traffic until epoxy adhesive has obtained full cure in accordance with manufacturer’s specifications.

3.1. **Metal Railing**.

3.1.1. **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.

Prepare and submit for approval the required shop or erection drawings in accordance with Item 441, “Steel Structures,” when the plans require. 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.”

3.1.2. **Fabrication**. Fabricate metal railing and post panels in sections conforming to the details shown on the plans and field-verified lines and grades. Fabricate adjacent sections so they will accurately engage each other in the field. Match-mark each pair of sections so they can be erected in the same position 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 feet 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. Bolts and nuts for metal railing should meet requirements of ASTM A307 and be galvanized in accordance with Item 445, “Galvanizing,” unless otherwise shown on the plans.

Fabricate aluminum in accordance with AWS D1.2.

Heat aluminum materials other than castings to a temperature up to 400°F for no more than 30 min. to facilitate bending or straightening.

3.1.3. **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 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. Heat-treat the entire lot of castings to the specified temper when required.

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 at least 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.

3.1.4. **Corrosion Protection**. Galvanize all portions of steel railing after fabrication in accordance with Item 445, “Galvanizing,” unless otherwise noted on the plans. Apply appearance coat to galvanized surface in accordance with Item 445, “Galvanizing,” when shown on the plans. When painting is specified in place of galvanizing, shop paint steel in accordance with Item 441, “Steel Structures.” Repair any damage to galvanized or painted surfaces after erection in accordance with Items 445, “Galvanizing,” and Item 446, “Field Cleaning and Painting Steel,” respectively.

Before final acceptance, clean surfaces of aluminum and galvanized steel railing not shown to be painted to remove extrusion marks, grease, dirt, and all other surface contaminants.

3.1.5. **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.

3.2. **Concrete Railing**. Provide concrete portions of railing in accordance with the requirements of Item 420, "Concrete Substructures," and Item 422, "Concrete Superstructures." Construct forms so 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 Structural Members (Fabrication)."

Slipform construction of railing is permitted unless otherwise shown on the plans. Demonstrate slipforming method showing line and grade of concrete surfaces can be consistently obtained and clear cover outside reinforcing steel be maintained at all times. Stop slipforming railing if specified concrete clear cover is not obtained or appearance of rail is off line and grade.

Do not slipform railing with cast-in-place anchor bolts unless noted otherwise.

Provide additional reinforcing as needed to prevent movement of the reinforcement cage. Clear cover and epoxy coating requirements for additional reinforcement are the same as shown for the rail reinforcement. The rail reinforcing cage may be tack welded to the rail anchorage reinforcement provided the rail and anchorage reinforcement are not epoxy coated and weld locations measured along the rail are no closer than 3 ft. Tie all bar intersections if epoxy coated reinforcement is required for the railing proposed to be slipformed. Provide a wire line to maintain vertical and horizontal alignment of the slipform machine. Attach a grade line gauge or pointer to the machine so a continuous comparison can be made between the rail being placed and the established grade line. Rails or supports at the required grade are allowed instead of sensor controls. Make one or more passes with the slipform over the rail segment to ensure proper operation and maintenance of grades and clearances before placing concrete. Provide slipformed rail within a vertical and horizontal alignment tolerance of ±1/4 in. per 10 feet. Construct rail with a smooth and uniform appearance. Consolidate concrete so it is free of honeycomb. Provide concrete with a consistency that will maintain the shape of the rail without support. Minimize starting and stopping of the slipform operation by ensuring a continuous supply of concrete.

Do not exceed the manufacturer's recommended speed for the slipform machine. Stop slipforming and take remedial action if slipforming causes movement of the reinforcement such that plan clearances are not achieved. Remove and replace unsatisfactory slipformed rail at the Contractor's expense.

3.3. **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.

The Engineer will select 3 anchor bars or bolts from the first day's production to be tested after the epoxy has cured. Test the bars or bolts in the presence of the Engineer in accordance with ASTM E1512, using a restrained test, to evaluate the epoxy adhesive's bond strength. Verify the anchor bars or bolts develop the required pullout resistance on the plans or 75% of the yield strength of the bars or bolts, whichever is less, without a bond failure of the epoxy. The Engineer may require additional tests during production. Perform corrective measures to provide adequate capacity if any of the tests do not meet the required test load. Repair damage from testing.

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.

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 “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 or bars, testing of epoxy anchors, 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 451
Retrofit Railing

1. DESCRIPTION

Retrofit or replace railing.

2. MATERIALS

Use materials that conform to requirements of the following Items.

- Item 421, “Hydraulic Cement Concrete,”
- Item 440, “Reinforcement for Concrete,”
- Item 441, “Steel Structures,”
- Item 442, “Metal for Structures,”
- Item 445, “Galvanizing,” and
- Item 540, “Metal Beam Guard Fence.”

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. Remove bolts to disassemble steel members unless otherwise approved. Incorporate reinforcing steel into the new concrete railing with at least 1-1/2 in. of clear cover if indicated on the plans. Cut off existing reinforcing steel at least 1 in. below the finished surface of the concrete if it cannot be reused as dowels. 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 on the plans and in accordance with Item 429, “Concrete Structure Repair.”

Dispose of removed material off the right of way in accordance with federal, state, and local regulations, unless otherwise shown on the plans. Carefully dismantle rail by unbolting steel members when plans specify to salvage rail members. Deliver materials to be retained by the Department to the location shown on the plans. Block up salvaged steel materials off the ground.

Construct replacement railing in accordance with Item 450, “Railing.”

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.

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 “Retrofit Railing” of the type specified. This price will be full compensation for removal and disposal of existing railing, disassembling and delivering members to be retained by the Department, repairing damaged bridge deck, furnishing, preparing, and placing concrete, expansion joint material, reinforcing steel, structural steel, aluminum, cast steel, pipe, anchor bolts or bars,

testing of epoxy anchors, and all other materials required in the finished railing; and hardware, paint and painting of metal railing, galvanizing, equipment, labor, tools, and incidentals.

Item 483
Concrete Bridge Deck Surfacing

1. DESCRIPTION

Surface concrete bridge deck as specified to provide prepared substrate for concrete overlay or to remediate a finished surface.

2. EQUIPMENT

Use equipment within the maximum allowed legal load or provide analysis showing equipment will not overstress the bridge. Use machines equipped with dust controls measures and shielding to prevent flying debris from leaving the work area.

2.1. **Milling**. Use concrete milling equipment capable of maintaining constant depth of cut as specified. Equip machine with automated debris collection system.

2.2. **Hydro-Demolition**. Use equipment consisting of ultra-high pressure water jets (> 10,000 psi) capable of removing concrete to depth specified. Provide machine that can to be calibrated to remove an incremental depth of uniform strength concrete.

2.3. **Shot Blasting**. Use self-propelled shot blasting equipment utilizing steel abrasive being propelled at the concrete surface and equipped with a self-contained vacuum system to collect all removed debris.

2.4. **Diamond Grinding**. Use self-propelled diamond grinding equipment capable of removing concrete surface and producing corduroy type texture. Provide machine equipped with dual longitudinal controls capable of operating on both sides automatically from any longitudinal grade reference and have cutting wheel containing 50 to 60 diamond blades per foot. Minimize dust escaping into environment by equipping machine with self-contained vacuum system to collect all debris removed.

2.5. **Saw Grooving**. 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, nominally 1/8 in. wide, and spaced at 1 in. Use sawing equipment capable of cutting grooves in hardened concrete to within 18 in. of the barrier rail or curb.

3. CONSTRUCTION

Protect bridge joints, drains, and other appurtenances from surfacing operations. Following surfacing, clean the surface to remove all cuttings and debris. Dispose of all cuttings and debris properly.

Use chipping tools and other smaller approved concrete surfacing equipment in small areas not accessible to the large surfacing equipment.

Approval to begin work is not an endorsement of proposed equipment. If equipment fails to meet specification requirements, replacing equipment may be required. No additional time or compensation to adjust or replace equipment will be granted.

Perform concrete bridge deck surfacing as specified in accordance with the following listed methods:

3.1. **Milling**. Mill the existing deck to remove concrete to the depth specified. Provide a uniformly rough surface with a chipped appearance suitable for bonding a concrete overlay. Scarify at locations shown on the plans

or as directed to the depths shown on the plans. Measure the depth from the level of the existing surface to the high points on the scarified surface.

Ensure damage does not occur to the bridge slab reinforcing steel, armored joints, slab joints, drainage hardware, and other appurtenances. Stop milling operations if reinforcing steel is encountered. Proceed with further milling only when approved to do so.

Establish and maintain independent grade control for concrete scarifying operations when appropriate or required.

Use chipping tools to remove concrete in small areas not accessible to the mechanical scarifier.

3.2. **Hydro-Demolition**. Submit for approval water disposal plan associated with the work. Follow all water disposal requirements per federal, state, and local law. Temporarily plug all bridge drains near the area of work to prevent runoff as a result of the work from being released. Protect surrounding property and traffic from water spray and material dislodged.

Demonstrate hydro-demolition on test areas as designated to calibrate machine to obtain concrete removal depth and finish as specified and as approved. At a minimum, calibrate machine to remove all unsound concrete and sound concrete to the specified depth.

Remove additional concrete to obtain a minimum of 3/4 in. around the bars by hydro-demolition or other approved method if reinforcing steel is exposed.

Stop and recalibrate machine when depth of removal or surface roughness is different than approved.

3.3. **Shot Blasting**. Demonstrate shot blasting on test areas as designated to calibrate machine to obtain depth of surface removal required and to obtain finish as specified and as approved.

Do not alter grade or cross slope unless shown otherwise.

Maintain and adjust machine calibration to produce surfacing required.

3.4. **Diamond Grinding**. Demonstrate diamond grinding on designated area and obtain approval of finish produced.

Perform grinding in longitudinal direction. Grind surfaces on both sides of transverse joints to be flush (same elevation). Eliminate minor depressions by extra grinding as directed.

Produce a uniform surface with a longitudinal corduroy type texture that eliminates joint and crack faults. Maintain transverse cross slope to provide drainage across surface.

Repeat grinding until surface grade and cross slope satisfies ride requirements. Minimum ride requirements are 1/4 in. in 10 ft. unless shown otherwise.

Saw-cut transversely the ground areas to provide grooved surface in accordance with Section 483.3.5., “Sawing Grooving,” unless otherwise directed.

3.5. **Sawing Grooving**. Cut grooves into concrete surface perpendicular to the structure centerline. Cut grooves 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 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 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 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.

4. MEASUREMENT

This Item will be measured by the square yard of concrete bridge deck surfaced.

5. PAYMENT

The work performed and equipment furnished in accordance with the Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Milling Concrete Slab" to the depth required, "Hydro-Demolition" to the depth required, "Shot Blasting," "Diamond Grinding Slab," and "Saw Grooving." This price is full compensation for removing all material to the depths shown; preparing the surface; texturing the surface; saw grooving the surface; loading, hauling, unloading, and disposing of the cuttings; and equipment, labor, tools, and incidentals.

Item 495
Raising Existing Structures

1. DESCRIPTION

Raise existing structures as shown on the plans.

2. MATERIALS

Furnish materials in accordance with the following.

- Item 420, “Concrete Substructures,”
- Item 421, “Hydraulic Cement Concrete,”
- Item 442, “Metal for Structures,” and
- Item 434, “Bridge Bearings.”

3. CONSTRUCTION

Submit detailed plans to raise structure. Approval of plans is required before beginning raising work. A licensed professional engineer must sign and seal the plans. Clearly indicate the methods, materials, cribbing, falsework or other supports, and equipment proposed. Repair or replace by an approved method any portions of the structure damaged by the raising operation. Approval of these plans does not relieve the Contractor from responsibility for the completion of the work nor from liability for repair or replacement of damaged portions of the structure due to the methods approved and employed.

3.1. **Preparation of Plans**. Apply vertical and horizontal loads such that the load capacities in bearing, shear, and flexure are not exceeded for any material or member carrying the load. Indicate jack positions and capacities and temporary hardware attachments on the plans.

Avoid jacking against the bottom of the slab. Use a jack with a minimum capacity of 2 times the unfactored dead load. Higher jacking capacity may be required if a single member is to be lifted individually in a multi-girder unit. Prohibit traffic on the structure until the structure is supported by cribbing, falsework, or the final supports.

Provide suitable cribbing, falsework, or other supports once the span or unit is resting on its final supports to prevent the various spans or units from dropping due to jack failure or other causes during the lifting operation.

3.2. **Temporary Support Load Factors**. Factor dead, live, and horizontal loads, including dynamic load allowance, per AASHTO LRFD *Bridge Design Specifications*. Design temporary supports to carry 2 times the dead load if traffic will not be allowed until permanent supports are in place.

It is not necessary to factor dead, live, and horizontal loads if design capacities of temporary supports include minimum safety factors of 2.0. Documentation on proprietary or project-specific temporary supports must include acceptable loads and safety factors.

3.3. **Raising of Spans**. Verify anchor bolts, closed joints, or other appurtenances do not restrict vertical movement before jacking. Jack spans from the existing bent cap or temporary falsework unless otherwise shown on the plans.

Loosen and remove all anchor bolt nuts or cut the anchor bolts to allow free vertical movement before raising. Replace all damaged or cut anchor bolts either by butt welding to existing bolts or by drilling into the

existing concrete cap a minimum of 12 in. and grouting in new bolts. Do not damage the bent cap reinforcing steel when installing new anchor bolts. Replace all damaged or lost anchor bolt nuts. Weld in accordance with Item 448, “Structural Field Welding.”

Provide adequate guides or force to ensure vertical lifting and prevent drifting of the structure during the jacking operation. Immediately cease jacking operation if lifting causes damage to any portion of the structure. Provide pedestals as shown on the plans.

3.3.1. **Simple Spans with an Expansion Joint in the Deck at Every Bent**. Raise the span by jacking as shown on the plans. Raise all of the beams on one side of the bent simultaneously. Do not raise one end of a simple span more than 4 in. before raising the opposite end.

3.3.2. **Simple Beam Spans with a Continuous Deck Over the Bent**. Raise all beams on both sides of the bent simultaneously by jacking according to the plans. Do not raise one end of a span more than 2 in. before raising the opposite end of the span.

3.3.3. **Continuous Beams**. Raise the unit by jacking according to the approved plans. Raise all beams at a single bent simultaneously. The unit may be raised incrementally from bent to bent. Do not raise the unit more than 2 in. at any bent before raising it at the adjacent bents.

4. MEASUREMENT

This Item will be measured by the lump sum. Material for permanent steel pedestals will be measured in accordance with Item 442, “Metal for Structures,” and material for permanent concrete pedestals will be measured in accordance with Item 420, “Concrete Substructures.”

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 Substructures.”

Item 496
Removing Structures

1. DESCRIPTION

Remove and either dispose of or salvage structures.

2. CONSTRUCTION

2.1. **Demolition Plans**. Follow the demolition sequence shown on the plans for bridge structures to be removed, or submit a demolition plan if indicated on the plans. Include in the required demolition plan the type and location of equipment to be used, the method and sequence of removal of the structural elements, and a narrative indicating the stability of the partially demolished structure is maintained throughout the demolition process. Have these plans signed and sealed by a licensed professional engineer when demolished structure intersects active roadways and as otherwise shown on the plans. Submit required demolition plans at least 14 days before starting work unless otherwise directed. Department approval of these plans is not required, but the Department reserves the right to request modifications to the plans when work could affect the safety of the traveling public and when around other transportation facilities to remain in place. Notify the Department 30 days before starting any bridge demolition work to allow for required notifications to other agencies.

2.2. **Removal**.

2.2.1. **Pipes**. Avoid damaging appurtenances determined by the Engineer to be salvageable.

2.2.2. **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.

2.2.3. **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 on 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.

2.2.4. **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.

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

2.4. **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.

2.5. **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.

3. MEASUREMENT

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

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 demolition plan preparation, loading, hauling, disposal, stockpiling, removal of appurtenances, excavation and backfill, equipment, labor, tools, and incidentals.

Item 500
Mobilization

1. DESCRIPTION

Establish and remove offices, plants, and facilities. Move personnel, equipment, and supplies to and from the project or the vicinity of the project site to begin work or complete work on Contract Items. Bonds and insurance are required for performing mobilization.

For Contracts with emergency mobilization, provide a person and method of contact available 24 hrs. a day, 7 days a week unless otherwise shown on the plans. The time of notice will be the transmission time of the written notice or notice provided orally by the Department's representative.

2. MEASUREMENT

This Item will be measured by the lump sum or each as the work progresses. Mobilization is calculated on the base bid only and will not be paid for separately on any additive alternate items added to the Contract.

3. PAYMENT

For this Item, the adjusted Contract amount will be calculated as the total Contract amount less the lump sum for mobilization. Except for Contracts with callout or emergency work, mobilization will be paid in partial payments as follows:

- Payment will be made upon presentation of a paid invoice for the payment or performance bonds and required insurance,
- Payment will be made upon verification of documented expenditures for plant and facility setup. The combined amount for all these facilities will be no more than 10% of the mobilization lump sum or 1% of the total Contract amount, whichever is less,
- When 1% of the adjusted Contract amount for construction Items is earned, 50% of the mobilization lump sum bid or 5% of the total Contract amount, whichever is less, will be paid. Previous payments under this Item will be deducted from this amount,
- When 5% of the adjusted Contract amount for construction Items is earned, 75% of the mobilization lump sum bid or 10% of the total Contract amount, whichever is less, will be paid. Previous payments under the Item will be deducted from this amount,
- When 10% of the adjusted Contract amount for construction Items is earned, 90% of the mobilization lump sum bid or 10% of the total Contract amount, whichever is less, will be paid. Previous payments under this Item will be deducted from this amount,
- Upon final acceptance, 97% of the mobilization lump sum bid will be paid. Previous payments under this Item will be deducted from this amount, and
- Payment for the remainder of the lump sum bid for "Mobilization" will be made after all submittals are received, final quantities have been determined and when any separate vegetative establishment and maintenance, test, and performance periods provided for in the Contract have been successfully completed.

For projects with extended maintenance or performance periods, payment for the remainder of the lump sum bid for "Mobilization" will be made 6 months after final acceptance.

For Contracts with callout or emergency work, “Mobilization,” will be paid as follows:

- Payment will be made upon presentation of a paid invoice for the payment of performance bonds and required insurance,
- Mobilization for callout work will be paid for each callout work request, and
- Mobilization for emergency work will be paid for each emergency work request.

Item 502
Barricades, Signs, and Traffic Handling

1. DESCRIPTION

Provide, install, move, replace, maintain, clean, and remove all traffic control devices shown on the plans and as directed.

2. CONSTRUCTION

Comply with the requirements of Article 7.2., "Safety."

Implement the traffic control plan (TCP) shown on the plans.

Install traffic control devices straight and plumb. Make changes to the TCP only as approved. Minor adjustments to meet field conditions are allowed.

Submit Contractor-proposed TCP changes, signed and sealed by a licensed professional engineer, for approval. The Engineer may develop, sign, and seal Contractor-proposed changes. Changes must conform to guidelines established in the TMUTCD using approved products from the Department's Compliant Work Zone Traffic Control Device List.

Maintain traffic control devices by taking corrective action when notified. Corrective actions include, but are not limited to, cleaning, replacing, straightening, covering, and removing devices. Maintain the devices such that they are properly positioned and spaced, legible, and have retroreflective characteristics that meet requirements day or night and in all weather conditions.

The Engineer may authorize or direct in writing the removal or relocation of project limit advance warning signs. When project limit advance warning signs are removed before final acceptance, provide traffic control in accordance with the TMUTCD for minor operations as approved.

Remove all traffic control devices upon completion of the work as shown on the plans or as directed.

3. MEASUREMENT

Barricades, Signs, and Traffic Handling will be measured by the month. Law enforcement personnel with patrol vehicles will be measured by the hour for each person.

4. PAYMENT

4.1. **Barricades, Signs, and Traffic Handling**. Except for Contracts with callout work and work orders, 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 "Barricades, Signs, and Traffic Handling." This price is full compensation for installation, maintenance, adjustments, replacements, removal, materials, equipment, labor, tools, and incidentals.

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 "Barricades, Signs, and Traffic Handling." This price is full compensation for installation, maintenance, adjustments, replacements, removal, materials, equipment, labor, tools, and incidentals.

When the plans establish pay items for particular work in the TCP, that work will be measured and paid under pertinent Items.

4.1.1. **Initiation of Payment**. Payment for this Item will begin on the first estimate after barricades, signs, and traffic handling devices have been installed in accordance with the TCP and construction has begun.

4.1.2. **Paid Months**. Monthly payment will be made each succeeding month for this Item provided the barricades, signs, and traffic handling devices have been installed and maintained in accordance with the TCP until the Contract amount has been paid.

If, within the time frame established by the Engineer, the Contractor fails to provide or properly maintain signs and barricades in compliance with the Contract requirements, as determined by the Engineer, the Contractor will be considered in noncompliance with this Item. No payment will be made for the months in question, and the total final payment quantity will be reduced by the number of months the Contractor was in noncompliance.

4.1.3. **Maximum Total Payment Before Acceptance**. The total payment for this Item will not exceed 10% of the total Contract amount before final acceptance in accordance with Article 5.12., “Final Acceptance.” The remaining balance will be paid in accordance with Section 502.4.1.5., “Balance Due.”

4.1.4. **Total Payment Quantity**. The quantity paid under this Item will not exceed the total quantity shown on the plans except as modified by change order and as adjusted by Section 502.4.1.2., “Paid Months.” An overrun of the plans quantity for this Item will not be allowed for approving designs; testing; material shortages; closed construction seasons; curing periods; establishment, performance, test, and maintenance periods; failure to complete the work in the number of months allotted; nor delays caused directly or indirectly by requirements of the Contract.

4.1.5. **Balance Due**. The remaining unpaid months of barricades less non-compliance months will be paid on final acceptance of the project, if all work is complete and accepted in accordance with Article 5.12., “Final Acceptance.”

4.1.6. **Contracts with Callout Work and Work Orders**. The work performed and the materials furnished with this Item and measured as provided under “Measurement,” will be considered subsidiary to pertinent Items, except for federally funded Contracts.

4.2. **Law Enforcement Personnel**. The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement,” will be paid by Contractor force account for “Law Enforcement Personnel.” This price is full compensation for furnishing all labor, materials, supplies, equipment, patrol vehicle, fees, and incidentals necessary to complete the work as directed.

Item 504
Field Office and Laboratory

1. DESCRIPTION

Provide field offices and laboratories for exclusive use of the Engineer and inspection staff.

2. EQUIPMENT

2.1. **General**. Furnish facilities after receipt of the work order and before beginning physical work on the project. Provide field offices of the type and number specified near the worksite at an acceptable location. If desired, use permanent buildings or rental space meeting the requirements for field offices instead of portable buildings only if approved. Maintain the field office until the Department accepts the project. Furnish other equipment as required.

Provide inspection laboratories of the type specified before beginning the fabrication of products required by the Contract. Locate the building so that plant operations are visible from the building. Maintain the laboratories until the production of the associated product is complete.

Immediately repair or replace facilities if damaged in any manner. Payment for repair will not be made unless it is the result of negligence by the Department. Reimburse the Department for equipment damaged by the Contractor's operations. Remove buildings and other facilities and restore the right of way before project acceptance when facilities are allowed in the right of way.

2.1.1. **Parking and Fencing**. Provide an all-weather parking area for the sole use of at least 2 State-owned vehicles unless otherwise shown on the plans. Situate the area near the field office or laboratory at an acceptable location. Maintain the parking area until the project is completed and restore the area to a condition acceptable to the Engineer upon project completion.

Enclose the field office or laboratory and the parking area with a 6-ft. chain-link fence, a top-mounted 3-strand barbed wire, and a 12-ft. gate when shown on the plans.

2.1.2. **Buildings**.

2.1.2.1. **Field Office**. Provide field offices with roof, floor, doors, and screened windows. Ensure the floor is strong enough to support testing equipment and has an impervious floor covering. Ensure that the field office is tied down, weatherproof, piped for water and fuel, and electrically wired by personnel meeting the requirements of Article 7.18., "Electrical Requirements."

Furnish and install adequate equipment, outlets, lighting, air-conditioning, heating, and ventilation. Provide a partitioned restroom furnished with restroom supplies, a lavatory, and a flush toilet connected to a sewer or septic tank. If desired, furnish a portable toilet only when approved.

Provide secured and controlled access to the field office or laboratory through security measures such as bars, alarms, or security fencing. Furnish steps to the structures if directed.

2.1.2.2. **Laboratory**. Provide laboratories with all of the requirements described in Section 504.2.1.2.1., "Field Office." In addition, provide the following items unless otherwise directed:

- a 10 lb. ABC fire extinguisher with up-to-date inspection tag and a working smoke detector;
- laboratory equipment necessary for testing when shown on the plans;
- water (for testing purposes) from an approved source;

- an exhaust fan for concrete curing, asphalt, or other operations to meet Department and OSHA requirements (Vent all exhaust to the outside of the structure.);
- a work platform at least 18 in. long and 12 in. wide, mounted on a lumber post at least 6 × 6 in. extending through the floor and firmly fixed in the ground (The work platform support can be provided by other methods as shown on the plans or as directed.);
- a minimum of 20 ft. of total work counter length at least 3 ft. wide and 3 ft. above the floor and strong enough to support required testing equipment; and
- a laboratory sink measuring 24 × 30 in. and 12 in. deep.

2.1.3. **Field Office and Laboratory Appurtenances**. Provide workbenches and tables at least 3 ft. wide and 6 ft. long, chairs, and filing cabinets in an approved quantity. Provide solar screens, blinds, or shades if directed. Provide approved potable water, electricity, collection and disposal of trash, and janitorial services.

Provide internet connectivity, a printer/fax/scan/copier, and telephone if shown on the plans.

Provide a closet within the facility for Contracts that require a nuclear gauge for moisture or density determination, or a separate structure for storage of the gauge located as far as possible from normal office work. Provide internal keyed deadbolt locks and hinges with pins on the inside of the storage area for all doors allowing access to the nuclear gauge.

2.2. **Structure Types**.

2.2.1. **Type A Structure (Field Laboratory)**. Provide at least 200 sq. ft. of gross floor area in rooms 8 ft. high. Partition the building into at least 2 rooms, each furnished with an exterior door and at least 2 windows.

2.2.2. **Type B Structure (Field Office and Laboratory)**. Provide at least 600 sq. ft. of gross floor area in rooms 8 ft. high. Partition the floor area into at least 3 interconnected rooms with doors, 2 exterior doors, and at least 2 windows in each room.

2.2.3. **Type C Structure (Field Office)**. Provide at least 400 sq. ft. of gross floor area in rooms 8 ft. high. Partition the floor area into at least 2 interconnected rooms with doors, 2 exterior doors, and at least 2 windows in each room.

2.2.4. **Type D Structure (Asphalt Mix Control Laboratory)**. Provide at least 700 sq. ft. of gross floor area in rooms 8 ft. high. Partition the floor area into at least 2 interconnected rooms with doors, 2 exterior doors, and at least 2 windows in each room.

2.2.4.1. **Asphalt Content by Ignition Method**. Provide enough power ventilation for the room, a NEMA 6-50R (208/240 V, 50 A) outlet within 3 ft. of the ignition oven location, and an independent exhaust outlet no farther than 8 ft. from the oven when asphalt content is determined by the ignition method. Provide a surface for the ignition oven that is level, sturdy, and fireproof with at least 6 in. of clearance between the furnace and other vertical surfaces.

Vent the ignition oven to the outside.

2.2.5. **Type E Structure**. Provide building as shown on the plans.

3. MEASUREMENT AND PAYMENT

The work performed, materials furnished, utilities and utility service (including phone if required), appurtenances (including office equipment and Internet service), testing equipment, labor, tools, and incidentals will not be measured or paid for directly but will be subsidiary to pertinent Items.

Item 512
Portable Traffic Barrier

1. DESCRIPTION

Furnish, install, move, and remove portable traffic barrier.

2. MATERIALS

2.1. **Furnished by the Contractor.**

2.1.1. **Concrete.** Furnish barrier of the class of concrete shown and using materials that meet the pertinent requirements of the following Items:

- Item 420, “Concrete Substructures”
- Item 421, “Hydraulic Cement Concrete”
- Item 424, “Precast Concrete Structural Members (Fabrication)”
- Item 440, “Reinforcement for Concrete”
- Item 442, “Metal for Structures”

2.1.2. **Steel.** Barrier sections will be furnished when shown on the plans. Barrier sections must meet the crash testing requirements of NCHRP 350 or MASH TL-3 or TL-4 specifications as per test matrix for Longitudinal Barriers.

2.1.3. **Concrete and Steel.** When barrier is to be furnished and retained by the Contractor, products from nonapproved sources or previously used products 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-section dimension requirements,
- there is no evidence of structural damage such as major spalls or cracks,
- the general condition of both the barrier sections and their connectors is acceptable,
- the barrier is new, and
- the barrier is being reused.

2.2. **Furnished by the Department.** Department-furnished barrier sections will be at a stockpile location or an existing traffic barrier installation shown on the plans.

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 Structural Members (Fabrication),” that produce concrete traffic barrier, except temporary barrier furnished and retained by the Contractor, must be qualified in accordance with DMS-7350, “Qualification Procedure for Multi-Project Fabrication Plants of Precast Concrete Traffic Barrier.” See the Department’s MPL for approved fabricators. Construct barrier in accordance with Item 420, “Concrete Substructures,” to the dimensions and cross-sections shown on the plans. Provide forms and cure concrete in accordance with Item 424, “Precast Concrete Structural Members (Fabrication).”

Provide a rough texture to the bottom surface of Single Slope or F-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. Move barrier sections to a storage area and place them on blocking to prevent damage when they have attained sufficient strength to permit handling without causing visible 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 in.
Insert Placement	±1/2 in.
Horizontal Alignment	±1/8 in. per 10 feet of length
Deviation of Ends:	
Horizontal Skew	±1/4 in.
Vertical Batter	±1/8 in. per foot of depth

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

After use, stockpile barrier sections and connection hardware that are to be retained by the Department at the location shown on the plans or as otherwise directed. Obtain assembly and installation information for the portable steel traffic barrier from the manufacturer, and provide the Engineer with an installation and repair manual specific to the portable steel traffic barrier.

Repair or replace all 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 sections at the Contractor's expense.

4. MEASUREMENT

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

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 as follows:

- For concrete barrier only, bid for "Portable Traffic Barrier" of the work category (Furnish and Install, Designated Source, Move, Stockpile, or Remove), shape (e.g., Single Slope, F-Shape, or Low Profile) and Type (1, 2, 3, etc.) of barrier sections specified. This price includes equipment, labor, tools, and incidentals.
- For concrete and steel barrier, bid for "Portable Traffic Barrier" of the work category (Furnish and Install, Designated Source, Move, Stockpile, or Remove), shape (e.g., Single Slope, F-Shape, or Low Profile) and Type (1, 2, 3, etc.) of barrier sections specified or "Steel". This price includes equipment, labor, tools, and incidentals.

5.1. **Furnish and Install**. This price is full compensation for furnishing and installing barrier sections and connection hardware.

5.2. **Designated Source**. This price is full compensation for delivering and installing Department-furnished barrier sections and connection hardware from a designated source.

5.3. **Move**. This price is full compensation for moving barrier section installations on the project from one location to another (including disassembly and reassembly costs), moving barrier sections from an installation on the project to a temporary storage area (including disassembly costs), and moving barrier sections from a temporary storage area to an installation site on the project (including assembly costs).

5.4. **Stockpile**. This price is full compensation for removing barrier sections and connection hardware from the project and delivering to the Department stockpile area shown on the plans or as directed.

5.5. **Remove**. This price is full compensation for removing barrier and connection hardware from the project and retained by the Contractor.

Item 529

Concrete Curb, Gutter, and Combined Curb and Gutter

1. DESCRIPTION

Construct hydraulic cement concrete curb, gutter, and combined curb and gutter.

2. MATERIALS

Furnish materials conforming to:

- Item 360, “Concrete Pavement”
- Item 420, “Concrete Substructures”
- Item 421, “Hydraulic Cement Concrete”
- Item 440, “Reinforcement for Concrete”

Use Class A concrete or material specified on the plans. Use Grade 8 coarse aggregate for extruded Class A concrete. Use other grades if approved.

When approved, use fibers meeting the requirements of DMS-4550, “Fibers for Concrete,” to replace reinforcing steel in Class A concrete. Dose fibers in accordance with the Department’s MPL of pre-qualified fibers for concrete.

3. CONSTRUCTION

Provide finished work with a well-compacted mass and a surface free from voids and honeycomb, in the required shape, line, and grade. Round exposed edges with an edging tool of the radius shown on the plans. Mix, place, and cure concrete in accordance with Item 420, “Concrete Substructures.” Construct joints at locations shown on the plans. Cure for at least 72 hr.

Furnish and place reinforcing steel in accordance with Item 440, “Reinforcement for Concrete.”

Set and maintain a guideline that conforms to alignment data shown on the plans, with an outline that conforms to the details shown on the plans. Ensure that changes in curb grade and alignment do not exceed 1/4 in. between any 2 contacts on a 10-ft. straightedge.

3.1. **Conventionally Formed Concrete**. Shape and compact subgrade, foundation, or pavement surface to the line, grade, and cross-section shown on the plans. Lightly sprinkle subgrade or foundation material immediately before concrete placement.

Pour concrete into forms, and strike off with a template 1/4 to 3/8 in. less than the dimensions of the finished curb unless otherwise approved. After initial set, plaster surface with mortar consisting of 1 part hydraulic cement and 2 parts fine aggregate. Brush exposed surfaces to a uniform texture.

Place curbs, gutters, and combined curb and gutters in 50-ft. maximum sections unless otherwise approved.

3.2. **Extruded or Slipformed Concrete**. Hand-tamp and sprinkle subgrade or foundation material before concrete placement. Provide clean surfaces for concrete placement. Coat cleaned surfaces, if required, with approved adhesive or coating at the rate of application shown on the plans or as directed. Place concrete with approved self-propelled equipment.

The forming tube of the extrusion machine or the form of the slipform machine must be easily adjustable vertically during the forward motion of the machine to provide variable heights necessary to conform to the established gradeline.

Attach a pointer or gauge to the machine so that a continual comparison can be made between the extruded or slipform work and the grade guideline. Other methods may be used when approved.

Finish surfaces immediately after extrusion or slipforming.

4. MEASUREMENT

This Item will be measured by the foot.

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 Curb," "Concrete Curb (Mono)," or "Concrete Curb and Gutter" of the type specified. This price is full compensation for surface preparation of curb foundation, equipment, labor, materials, tools, and incidentals.

Item 544
Guardrail End Treatments

1. DESCRIPTION

Furnish and install, move, or remove guardrail end treatments.

2. MATERIALS

Furnish new materials from the Department's MPL of rail element manufacturers. Obtain materials at the location shown on the plans when furnished by the Department.

3. CONSTRUCTION

Install guardrail end treatments in accordance with manufacturer's assembly and installation requirements and the details shown on the plans. Provide the Engineer with manufacturer's installation and repair manuals specific to the guardrail end treatment.

Move or remove guardrail end treatments in accordance with the plans and as directed. Deliver salvageable materials in accordance with the plans or as directed. Dispose of unsalvageable materials in accordance with federal, state, and local regulations.

4. MEASUREMENT

This Item will be measured by each guardrail end treatment.

5. PAYMENT

The work performed and the materials furnished in accordance with this Item and measured as provided for under "Measurement" will be paid for at the unit price bid for "Guardrail End Treatment (Install)" of the post and type specified where applicable, "Guardrail End Treatment (Move and Reset)," or "Guardrail End Treatment (Remove)." This price is full compensation for foundations, materials, stockpiling, disposal of unsalvageable materials, equipment, labor, tools, and incidentals.

Payment for "Guardrail End Treatment (Move and Reset)" will include each guardrail end treatment removed from a stockpile or from an existing location and reset in a new location as detailed on the plans or as directed.

Payment for "Guardrail End Treatment (Remove)" will include each guardrail end treatment removed from an existing location and stockpiled at the location designated on the plans, disposed, or as otherwise directed.

Item 545
Crash Cushion Attenuators

1. DESCRIPTION

Furnish and install, move and reset, or remove crash cushion attenuators.

2. MATERIALS

2.1. **Crash Cushion Attenuators**. Furnish new crash cushion attenuators in accordance with the details shown on the plans and on the manufacturer's shop drawings. Obtain crash cushion attenuators at the location shown on the plans when furnished by the Department.

2.2. **Concrete**. Furnish Class S concrete for pads that meets Item 421, "Hydraulic Cement Concrete."

3. CONSTRUCTION

Perform the following as shown on the plans:

3.1. **Installation**. Assemble and install crash cushion attenuators in accordance with the details shown on the plans and manufacturer recommendations. Obtain assembly and installation information for the crash cushion attenuators from the manufacturer and provide the Engineer with an installation and repair manual specific to the crash cushion attenuators.

3.2. **Moving and Resetting**. Remove crash cushion attenuators from a stockpile or from an existing location and reset in a new location as shown on the plans or as directed. Install crash cushion attenuators in accordance with pertinent standards and manufacturer recommendations. Provide additional materials to complete the installation as needed. Dispose of unsalvageable materials in accordance with federal, state, and local regulations.

3.3. **Removal**. Remove crash cushion attenuators from an existing location and stockpile in the area designated on the plans, as directed, or dispose. Clean and repair salvageable units before inspection and return them to the Department. Dispose of unsalvageable materials in accordance with federal, state, and local regulations.

4. MEASUREMENT

This Item will be measured by each crash cushion attenuator.

5. PAYMENT

The work performed and the materials furnished in accordance with this Item and measured as provided for under "Measurement" will be paid for at the unit price bid for "Crash Cushion Attenuator (Furnish and Install, Designated Source, Move and Reset, Stockpile, or Remove)" of the category, width (N or W), and test level. This price is full compensation for foundations; materials, stockpiling, moving and removing, hauling, installing and resetting, disposal of unsalvageable materials, equipment, labor, tools, and incidentals.

5.1. **Furnish and Install**. This price is full compensation for furnishing and installing crash cushion attenuator.

5.2. **Designated Source**. This price is full compensation for delivering and installing Department-furnished crash cushion attenuator from a designated source.

5.3. **Move and Reset**. This price is full compensation for moving crash cushion attenuator installations on the project from one location to another (including disassembly and reassembly costs), moving crash cushion attenuator from an installation on the project to a temporary storage area (including disassembly costs), and moving crash cushion attenuator from a temporary storage area to an installation site on the project (including assembly costs).

5.4. **Stockpile**. This price is full compensation for removing crash cushion attenuator from the project and delivering to the Department stockpile area shown on the plans or as directed.

5.5. **Remove**. This price is full compensation for removing crash cushion attenuator from the project and retained by the Contractor.

Item 636
Signs

1. DESCRIPTION

- **Installation**. Furnish, fabricate, and erect aluminum signs. Sign supports are provided for under other Items.
- **Replacement**. Replace existing signs on existing sign supports.
- **Refurbishing**. Refurbish existing aluminum signs on existing sign supports.

2. MATERIALS

2.1. **Sign Blanks**. Furnish sign blank substrates in accordance with DMS-7110, "Aluminum Sign Blanks," and in accordance with the types shown on the plans. Use single-piece sheet-aluminum substrates for Type A (small) signs and extruded aluminum substrates for Type G (ground-mounted) or Type O (overhead-mounted) signs.

2.2. **Sign Face Retroreflectorization**. Retroreflectorize the sign faces with flat surface reflective sheeting. Furnish sheeting that meets DMS-8300, "Sign Face Materials." Use retroreflective sheeting from the same manufacturer for the entire sign face background. Ensure that sign legend, symbols, borders, and background exhibit uniform color, appearance, and retroreflectivity when viewed both day and night.

2.3. **Sign Messages**. Fabricate sign messages to the sizes, types, and colors shown on the plans. Use sign message material from the same manufacturer for the entire message of a sign. Use screen ink and background reflective sheeting that are from the same manufacturer when fabricating signs.

- Ensure that the screened messages have clean, sharp edges and exhibit uniform color and retroreflectivity. Prevent runs, sags, and voids. Furnish screen inks in accordance with DMS-8300, "Sign Face Materials."
- Fabricate colored, transparent film legend, and retroreflectorized sheeting legend from materials that meet DMS-8300, "Sign Face Materials."
- Fabricate non-reflective black film legend from materials meeting DMS-8300, "Sign Face Materials."
- Furnish direct-applied route markers and other attachments within the parent sign face unless otherwise specified on the plans.

2.4. **Hardware**. Use galvanized steel, stainless steel, or dichromate-sealed aluminum for bolts, nuts, washers, lock washers, screws, and other sign assembly hardware. Use plastic or nylon washers to avoid tearing the reflective sheeting. Furnish steel or aluminum products in accordance with DMS-7120, "Sign Hardware."

When dissimilar metals are used, select or insulate metals to prevent corrosion.

3. CONSTRUCTION

3.1. **Fabrication**. Sign fabrication plants that produce permanent highway signs must be approved in accordance with DMS-7390, "Permanent Highway Sign Fabrication Plant Qualification." Furnish signs from prequalified fabrication plants listed in the Department's MPL.

3.1.1. **Sign Blanks**. Furnish sign blanks to the sizes and shapes shown on the plans and that are free of buckles, warps, burrs, dents, cockles, or other defects. Do not splice individual extruded aluminum panels.

Complete the fabrication of sign blanks, including the cutting and drilling or punching of holes, before cleaning and degreasing. After cleaning and degreasing, ensure the substrate does not come into contact with grease, oils, or other contaminants before the application of the reflective sheeting.

3.1.2. **Sheeting Application**. Apply sheeting to sign blanks in conformance with the sheeting manufacturer's recommended procedures.

When using rotational sensitive white sheeting, fabricate signs by applying the sheeting for cut-out legend, symbols, borders, and route marker attachments within the parent sign face with the identification marks or other orientation features in the optimum rotation as identified by the sheeting manufacturer.

Clean and prepare the outside surface of extruded aluminum flanges in the same manner as the sign panel face.

Minimize the number of splices in the sheeting. Overlap the lap-splices by at least 1/4 in. for encapsulated glass bead sheeting unless otherwise recommended by the reflective sheeting manufacturer. Use butt splices for prismatic reflective sheeting. Provide a 1 ft. minimum dimension for any piece of sheeting. Do not splice sheeting for signs fabricated with transparent screen inks or colored transparent films.

3.1.3. **Sign Assembly**. Assemble extruded aluminum signs in accordance with the details shown on the plans. Sign face surface variation must not exceed 1/8 in. per foot. Surface misalignment between panels in multi-panel signs must not exceed 1/16 in. at any point.

3.1.4. **Decals**. Code and apply sign identification decals in accordance with Item 643, "Sign Identification Decals."

3.2. **Storage and Handling**. Ship, handle, and store completed sign blanks and completed signs so that corners, edges, and faces are not damaged. Damage to the sign face that is not visible when viewed at a distance of 50 ft., night or day, will be acceptable. Replace unacceptable signs.

Store all finished signs off the ground and in a vertical position until erected. Store finished sheet aluminum substrate signs in a weatherproof building. Extruded aluminum substrate signs may be stored outside.

Stockpile salvageable materials at the location shown on the plans or as directed. Accept ownership of unsalvageable materials and dispose of them in accordance with federal, state, and local regulations.

3.3. **Cleaning**. Wash completed signs in the fabrication shop with a biodegradable cleaning solution acceptable to the manufacturers of the sheeting, colored transparent film, and screen ink to remove grease, oil, dirt, smears, streaks, finger marks, and other foreign material. Wash again before final inspection after erection.

3.4. **Installation**. Install signs as shown on the plans or as directed.

3.5. **Replacement**. Remove the existing signs from the existing supports and replace with new signs, including mounting hardware, as shown on the plans.

3.6. **Refurbishing**. Refurbish existing signs by providing and installing new messages and mounting hardware. Install new retroreflectorized legend and supplemental signs as shown on the plans.

3.7. **Documentation**. Provide the following documentation from the sign fabricator with each shipment of furnished signs:

- A notarized original of the Signing Material Statement (Form 2273) with the proper attachments for verification of compliance, and
- A notarized certification stating that the completed signs were fabricated in accordance with this Item and the plans.

4. MEASUREMENT

Signs installed or replaced will be measured by the square foot of the sign face. Signs refurbished will be measured by each sign.

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.

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 "Aluminum Signs," "Replacing Existing Aluminum Signs," or "Refurbishing Aluminum Signs," of the type specified.

5.1. **Installation**. This price is full compensation for furnishing and installing new signs and hardware; fabrication of sign panels; treatment of sign panels required before application of the background materials; application of the background materials and messages to the sign panels; furnishing and fabricating frames, wind beams and stiffeners; furnishing bolts, rivets, screws, fasteners, clamps, brackets, and sign support connections; assembling and erecting the signs; preparing and cleaning the signs; and materials, equipment, labor, tools, and incidentals.

5.2. **Replacement**. This price is full compensation for furnishing and installing new aluminum signs and hardware; removal of existing signs; fabrication of sign panels; treatment of sign panels required before application of the background materials; application of the background materials and messages to the sign panels; furnishing and fabricating frames, wind beams and stiffeners; furnishing bolts, rivets, screws, fasteners, clamps, brackets, and sign support connections; assembling and erecting the signs; preparing and cleaning the signs; salvaging and disposing of unsalvageable materials; and materials, equipment, labor, tools, and incidentals.

5.3. **Refurbishing**. This price is full compensation for modifying existing sign messages; removing and replacing existing route markers, reflectorized legend, or supplemental signs attached to the parent sign; preparing and cleaning the signs; furnishing sheeting and hardware; salvaging and disposing of unsalvageable materials; and materials, equipment, labor, tools, and incidentals.

Item 643
Sign Identification Decals

1. DESCRIPTION

Furnish and install sign identification decals.

2. MATERIALS

Furnish materials that meet the requirements of DMS-8315, "Sign Identification Decals."

Figure 1 shows the sign identification decal design. Table 1 describes the information required in each row of the decal.

Texas Department of Transportation												
C	**Fabrication Date**										**T**	**1**
J	F	M	A	M	J	J	A	S	O	N	D	**2**
	201		202		203		204		205			**3**
	0	1	2	3	4	5	6	7	8	9		**4**
Sheeting MFR - Substrate												
A	B	C	D	E	F	G	H	J	K	L	M	**5**
Film MFR												
A	B	C	D	E	F	G	H	J	K	L	M	**6**
Sheeting MFR - Legend												
A	B	C	D	E	F	G	H	J	K	L	M	**7**
Installation Date												
				0	1	2	3					**8**
	0	1	2	3	4	5	6	7	8	9		**9**
J	F	M	A	M	J	J	A	S	O	N	D	**10**
	201		202		203		204		205			**11**
	0	1	2	3	4	5	6	7	8	9		**12**

Figure 1
Decal Design (Row numbers explained in Table 1.)

Table 1
Decal Description

Row Explanation
1 – Sign Fabricator
2 – Month Fabricated
3 – First 3 Digits of Year Fabricated
4 – Last Digit of Year Fabricated
5 – Manufacturer of the Sheeting Applied to the Substrate
6 – Film (colored transparent or non-reflective black) Manufacturer
7 – Manufacturer of the Sheeting for the Legend
8 – Tens digit of Date Installed
9 – Ones Digit of Date Installed
10 – Month Installed
11 – First 3 Digits of Year Installed
12 – Last Digit of Year Installed

3. CONSTRUCTION

3.1. **Sign Fabricator**. Code the decal by punching out the following:

- "C" if fabricated by a commercial sign fabricator or "T" if fabricated by the Department or the Texas Department of Criminal Justice;
- month fabricated;
- first 3 digits of the year fabricated;
- fourth digit of the year fabricated; and
- sheeting, film, and ink manufacturers. (Codes for these manufacturers are located in the Department's MPL.)

Affix decal to lower left corner of the sign back in an upright position.

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 pertinent Items.

Item 644
Small Roadside Sign Assemblies

1. DESCRIPTION

- **Installation**. Furnish, fabricate, and erect small roadside sign assemblies or bridge mounted clearance sign assemblies consisting of the signs, sign supports, foundations (when required), and associated mounting hardware.
- **Relocation**. Relocate existing small roadside sign assemblies or bridge mounted clearance sign assemblies, and furnish and fabricate material as required.
- **Removal**. Remove existing small roadside sign assemblies or bridge mounted clearance sign assemblies.

2. MATERIALS

Furnish all materials unless otherwise shown on the plans. Furnish only new materials. Furnish and fabricate materials that comply with the following Items and details shown on the plans:

- Item 421, “Hydraulic Cement Concrete”
- Item 440, “Reinforcement for Concrete”
- Item 441, “Steel Structures”
- Item 442, “Metal for Structures”
- Item 445, “Galvanizing”
- Item 636, “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 metals to prevent corrosion.

3. CONSTRUCTION

Construct 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.

3.1. **Fabrication**. Fabricate sign supports in accordance with Item 441, “Steel Structures.” Ensure 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.

Hot-dip galvanize fabricated parts in accordance with Item 445, “Galvanizing.” Punch or drill any holes in steel parts or members before galvanizing. Repair galvanizing for any steel part or member damaged during assembly, transit, erection; or for any steel part or member welded, when permitted, after galvanizing. Perform all galvanizing repairs in accordance with Section 445.3.5., “Repairs.”

3.2. **Installation**. Locate and install sign supports as shown on the plans, unless directed to shift the sign supports within design guidelines to secure a more desirable location or 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 supports in accordance with the plans and pertinent Items.

3.3. **Relocation**. Reuse the existing signs as required unless otherwise shown on the plans. Furnish and install new stub posts in new foundations for relocated sign assemblies. Erect the new supports on the new stub posts, and attach the existing signs to the supports in accordance with the plans and pertinent Items. Remove existing foundations to be abandoned in accordance with Section 644.3.4., "Removal."

3.4. **Removal**. Remove abandoned concrete foundations to 2 ft. below finish grade unless otherwise shown on the plans. Cut off and remove steel protruding from the remaining concrete. Backfill the remaining hole with material equal in composition and density to the surrounding area. Replace any surfacing with like material to equivalent condition.

3.5. **Handling and Storage**. Handle and store existing signs or portions of signs removed so 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 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.

3.6. **Cleaning**. Wash the entire sign after installation with a biodegradable cleaning solution acceptable to the sign face materials manufacturer to remove dirt, grease, oil smears, streaks, finger marks, and other foreign materials.

4. MEASUREMENT

This Item will be measured as each small roadside assembly or bridge mounted clearance sign assembly installed, removed, or relocated.

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 Assemblies" of the type specified, "Install Bridge Mounted Clearance Sign Assemblies" of the type specified, "Relocate Small Roadside Sign Assemblies" of the type specified, "Relocate Bridge Mounted Clearance Sign Assemblies" of the type specified, "Remove Small Roadside Sign Assemblies," or "Remove Bridge Mounted Clearance Sign Assemblies."

5.1. **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; preparing and cleaning the signs; and materials, equipment, labor, tools, and incidentals.

5.2. **Relocation**. This price is full compensation for removing existing sign assemblies and related materials; furnishing and installing new stub posts and new sign supports; constructing foundations including concrete (when required); and new hardware; reinstallation of signs; preparing and cleaning the signs; salvaging;

disposal of unsalvageable materials; removing existing foundations, backfilling, and surface placement; and materials, equipment, labor, tools, and incidentals.

5.3. **Removal**. This price is full compensation for removing existing sign assemblies and related materials; salvaging; disposal of unsalvageable materials; removing existing foundations, backfilling, and surface placement; and materials, equipment, labor, tools, and incidentals.

Item 656
Foundations for Traffic Control Devices

1. DESCRIPTION

Construct concrete foundations for small roadside signs, traffic signal controllers, pedestal poles, roadside flashing beacon assemblies, electrical services, and other small traffic control devices.

2. MATERIALS

Ensure materials and construction methods conform to the requirements of this Item and the pertinent requirements of the following Items:

- Item 400, “Excavation and Backfill for Structures”
- Item 416, “Drilled Shaft Foundations”
- Item 420, “Concrete Substructures”
- Item 421, “Hydraulic Cement Concrete”
- Item 432, “Riprap”
- Item 440, “Reinforcement for Concrete”
- Item 441, “Steel Structures”
- Item 442, “Metal for Structures”
- Item 445, “Galvanizing”
- Item 447, “Structural Bolting”
- Item 449, “Anchor Bolts”
- Item 618, “Conduit”

Use Class A concrete for non-reinforced drilled shafts. Use Class C concrete for reinforced drilled shafts. Use Class B concrete or polymer concrete composed of borosilicate glass fiber, catalyzed polyester resin, and aggregate for traffic signal controller foundations. Use drilled shaft or galvanized steel screw-in type foundations for roadside flashing beacon assemblies.

Use reinforcing steel when required.

3. CONSTRUCTION

Stake and install foundations as shown on the plans. The Engineer may shift the foundation locations within design guidelines where necessary to secure a more desirable location or avoid conflict with utilities. Use established industry and utility safety practices when working near underground or overhead utilities. Consult the appropriate utility before beginning work.

Hold anchor bolts in place with templates during concrete placement. Hold embedded items such as conduit or other hardware in place during concrete placement with templates or other approved means. Cap conduits before placing concrete. Ream conduit to remove burrs and sharp edges. Install bell ends or bushings on the conduit.

Carefully align foundation, posts, and anchor bolts. Do not spring or rake posts or anchor bolts.

Remove the top template after concrete has achieved initial set. Keep forms and other bracing intact until the concrete has cured at least one curing day.

Allow concrete for pedestal poles and roadside flashing beacon assemblies to cure at least 7 days before placing bases and poles on the foundation unless otherwise permitted in writing.

Allow concrete for traffic signal controller foundations and small roadside signs to cure at least 4 days before placing cabinets and posts on the foundation unless otherwise permitted.

Provide an ordinary surface finish to the concrete foundation extending above ground in accordance with Section 420.4.13., “Ordinary Surface Finish.”

Place concrete riprap around the foundation in accordance with the plans.

Backfill disturbed surface with material equal in composition and density to the surrounding area. Replace surfacing material with similar material to an equivalent condition.

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 pertinent Items.

Item 658
Delineator and Object Marker Assemblies

1. DESCRIPTION

- **Installation**. Install delineator or object maker assembly.
- **Removal**. Remove delineator or object marker assembly.

2. MATERIALS

Furnish only new materials in accordance with details shown on the plans unless otherwise directed. The Engineer will sample in accordance with Tex-725-I or Tex-737-I.

2.1. **Delineator and Object Marker Assemblies**. Fabricate in accordance with the following:

- DMS-8600, "Delineators, Object Markers, and Barrier Reflectors."
- DMS-4400, "Flexible Delineator and Object Marker Posts (Embedded and Surface-Mount Types)."

2.2. **Wing Channel Post**. Furnish material of the size shown on the plans. Supply a notarized original of the Form D-9-USA-1 (Department Form 1818) with supporting mill test report certifying that the base metal is in accordance with the following:

- ASTM A1011, SS Grade 50.
- ASTM A499.

Galvanize material in accordance with Item 445, "Galvanizing."

3. CONSTRUCTION

3.1. **Installation**. Locate delineators and object markers as shown on the plans or as directed.

Locate barrier reflectors as shown on the plans or as directed, and install in accordance with manufacturers recommendations.

Install winged channel post and flexible delineator posts to allow the reflector units and reflectorized panels to be installed at the specified height and orientation. Align post as shown or as directed.

Drive post plumb using a driving cap to prevent visible cross-section dimension distortion. Drill or drive a pilot hole when post cannot be driven without visibly distorting the cross-section dimension. Backfill pilot holes thoroughly by tamping in 6-in. lifts to grade.

Install surface-mount and other types of delineators and object markers in accordance with details shown on the plans.

Repair damaged galvanizing in accordance with Section 445.3.5., "Repairs." Install reflector units on wing channel posts after the posts have been erected.

3.2. **Removal**. Remove post assemblies without damaging materials and salvage when indicated on the plans. Remove post to a minimum of 6 in. below finish grade. Stockpile salvaged materials at the location shown on the plans or as directed. Accept ownership of unsalvageable materials and dispose of in accordance with federal, state, and local requirements.

4. MEASUREMENT

Installation will be measured by each delineator or object marker assembly installed. When removal is specified on the plans to be a pay item, it will be measured by each delineator or object marker assembly removed.

This is a plans quantity measurement Item. The quantity to be paid for is 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.

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 Delineator Assemblies" or "Install Object Marker Assemblies" of the types and colors specified and for "Remove Delineator or Object Marker Assemblies."

5.1. **Installation**. This price is full compensation for furnishing and fabricating when required, and installing and mounting the delineator or object marker assemblies including posts, adhesive or pads for surface mount assemblies, back plates, reflector units, fastening plates, brackets, bolts, nuts, and washers; and materials, equipment, labor, tools, and incidentals.

5.2. **Removal**. Unless otherwise shown on the plans, removal will not be paid for directly but is subsidiary to bid items of the Contract.

When removal is shown on the plans as a bid item, this price is full compensation for removal and disposal of delineator and object marker assemblies and for materials, equipment, labor, tools, and incidentals.

Item 662
Work Zone Pavement Markings

1. DESCRIPTION

Furnish, place, and maintain work zone pavement markings.

2. MATERIALS

Provide thermoplastic, paint and beads, raised pavement markers (RPMs), prefabricated pavement markings, temporary flexible reflective roadway marker tabs, or other approved materials for work zone pavement markings.

Supply materials meeting:

- DMS-4200, "Pavement Markers (Reflectorized),"
- DMS-4300, "Traffic Buttons,"
- DMS-8200, "Traffic Paint,"
- DMS-8220, "Hot Applied Thermoplastic,"
- DMS-8240, "Permanent Prefabricated Pavement Markings,"
- DMS-8241, "Temporary (Removable) Prefabricated Pavement Markings,"
- DMS-8242, "Temporary Flexible, Reflective Roadway Marker Tabs," and
- DMS-8290, "Glass Traffic Beads."

2.1. **Nonremovable Markings**. Use hot-applied thermoplastic or permanent prefabricated pavement markings for nonremovable markings. Paint and beads or other materials are not allowed for nonremovable markings unless shown on the plans.

2.2. **Removable and Short-Term Markings**. Use RPMs, removable prefabricated pavement markings, temporary flexible reflective roadway marker tabs, or other approved materials for removable and short-term markings. Do not use hot-applied thermoplastic or traffic paint for removable markings. Use removable prefabricated pavement markings on the final pavement surface when the plans specify removable markings.

3. CONSTRUCTION

Apply pavement markings in accordance with the following Items.

- Item 666, "Retroreflectorized Pavement Markings"
- Item 668, "Prefabricated Pavement Markings"
- Item 672, "Raised Pavement Markers"

3.1. **Placement**. Install longitudinal markings on pavement surfaces before opening to traffic. Maintain lane alignment traffic control devices and operations until markings are installed. Install markings in proper alignment in accordance with the TMUTCD and as shown on the plans. Short-term markings will be allowed when standard markings (removable or nonremovable) cannot be placed before opening to traffic, if shown on the plans or directed.

When short-term markings are allowed for opening to traffic, place standard longitudinal markings no later than 14 calendar days after the placement of the surface. When inclement weather prohibits placement of markings, the 14-day period may be extended until weather permits proper application.

Place standard longitudinal markings no sooner than 3 calendar days after the placement of a surface treatment, unless otherwise shown on the plans.

Apply thermoplastic markings to a minimum thickness of 0.060 in. (60 mils). When paint and beads are allowed, apply to a minimum dry thickness of 0.012 in. (12 mils).

Place short-term markings in proper alignment with the location of the final pavement markings. Remove and replace short-term markings not in alignment at the Contractor's expense.

For removable placements, use of RPMs to simulate longitudinal markings is at the Contractor's option. Use side-by-side RPMs to simulate longitudinal lines wider than 4 in. Do not use RPMs for words, symbols, shapes, or diagonal or transverse lines.

3.2. **Marking Removal**. Remove markings that conflict with succeeding markings in accordance with Item 677, "Eliminating Existing Pavement Markings and Markers." Remove short-term markings that interfere or conflict with final marking placement immediately before placing final pavement markings, unless otherwise directed. Remove the remainder of the short-term markings before final acceptance.

Remove all temporary markings with minimal damage to the roadway to the satisfaction of the Engineer.

3.3. **Performance Requirements**. Ensure all markings are visible from a distance at least 300 ft. in daylight conditions and at least 160 ft. in nighttime conditions when illuminated by automobile low-beam headlights. Determine visibility distances using an automobile traveling on the roadway under dry conditions.

Maintain the markings for 30 calendar days after installation. The end of the 30-day maintenance period does not relieve the Contractor from the performance deficiencies requiring corrective action identified during the 30-day period. Remove and replace markings at the Contractor's expense if they fail to meet the requirements of this Item during the 30-day period. The 30-calendar day performance requirement will begin again after replacement of the markings.

Ensure daytime and nighttime reflected color of the markings are distinctly white or yellow. Ensure markings exhibit uniform retroreflective characteristics.

4. MEASUREMENT

This Item will be measured by the foot or each word, shape, symbol, or temporary flexible reflective roadway marker tab. Each stripe will be measured separately. RPMs used to simulate a marking will be measured by the foot of marking or each RPM.

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.

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 "Work Zone Pavement Markings" of the type and color specified and the shape, width, and size specified as applicable. This price is full compensation for furnishing, placing, maintaining, and removing work zone pavement markings and for materials, equipment, labor, tools, and incidentals.

Elimination of nonremovable markings will be paid for under Item 677, “Eliminating Existing Pavement Markings and Markers.” Removal of short-term and removable markings will not be paid for directly but will be subsidiary to this Item.

Type II work zone pavement markings (paint and beads) used as a sealer for Type I pavement markings (thermoplastic) will be paid for under this Item.

Item 666
Retroreflectorized Pavement Markings

1. DESCRIPTION

Furnish and place retroreflectorized, non-retroreflectorized (shadow) and profile pavement markings.

2. MATERIALS

2.1. **Type I Marking Materials**. Furnish in accordance with DMS-8220, "Hot Applied Thermoplastic."

Furnish pavement marking material used for Type I profile markings and shadow markings that have been approved by the Construction Division, and in accordance with DMS-8220, "Hot Applied Thermoplastic."

2.2. **Type II Marking Materials**. Furnish in accordance with DMS-8200, "Traffic Paint."

2.3. **Glass Traffic Beads**. Furnish drop-on glass beads in accordance with DMS-8290, "Glass Traffic Beads" or as approved. Furnish a double-drop of Type II and Type III drop-on glass beads where each type bead is applied separately in equal portions (by weight), unless otherwise approved. Apply the Type III beads before applying the Type II beads.

2.4. **Labeling**. Use clearly marked containers that indicate color, mass, material type, manufacturer, and batch number.

3. EQUIPMENT

3.1. **General Requirements**. Use equipment that:

- is maintained in satisfactory condition,
- meets or exceeds the requirements of the National Board of Fire Underwriters and the Texas Railroad Commission for this application,
- applies beads by an automatic bead dispenser attached to the pavement marking equipment in such a manner that the beads are dispensed uniformly and almost instantly upon the marking as the marking is being applied to the road surface. The bead dispenser must have an automatic cut-off control, synchronized with the cut-off of the pavement marking equipment,
- has an automatic cut-off device with manual operating capabilities to provide clean, square marking ends,
- is capable of producing the types and shapes of profiles specified, and
- can provide continuous mixing and agitation of the pavement marking material. The use of pans, aprons, or similar appliances which the die overruns will not be permitted for longitudinal striping applications.

Provide a hand-held thermometer capable of measuring the temperature of the marking material when applying Type I material.

When pavement markings are required to meet minimum retroreflectivity requirements on the plans:

- Use a mobile retroreflectometer approved by the Construction Division and certified by the Texas A&M Transportation Institute Mobile Retroreflectometer Certification Program.
- Use a portable retroreflectometer that:
  - uses 30-meter geometry and meets the requirements described in ASTM E1710;
  - has either an internal global positioning system (GPS) or the ability to be linked with an external GPS with a minimum accuracy rating of 16 ft. 5 in., in accordance with the circular error probability

(CEP) method (CEP is the radius of the circle with its origin at a known position that encompasses 50% of the readings returned from the GPS instrument);

- can record and print the GPS location and retroreflectivity reading for each location where readings are taken.

3.2. **Material Placement Requirements**. Use equipment that can place:

- at least 40,000 ft. of 4-in. solid or broken non-profile markings per working day at the specified thickness;
- at least 15,000 ft. of solid or broken profile pavement markings per working day at the specified thickness;
- linear non-profile markings up to 8 in. wide in a single pass;
- non-profile pavement markings other than solid or broken lines at an approved production rate;
- a centerline and no-passing barrier-line configuration consisting of 1 broken line and 2 solid lines at the same time to the alignment, spacing, and thickness for non-profile pavement markings shown on the plans;
- solid and broken lines simultaneously;
- white line from both sides;
- lines with clean edges, uniform cross-section with a tolerance of ±1/8 in. per 4 in. width, uniform thickness, and reasonably square ends;
- skip lines between 10 and 10-1/2 ft., a stripe-to-gap ratio of 10 to 30, and a stripe-gap cycle between 39-1/2 ft. and 40-1/2 ft., automatically;
- beads uniformly and almost instantly on the marking as the marking is being applied;
- beads uniformly during the application of all lines (each line must have an equivalent bead yield rate and embedment); and
- double-drop bead applications using both Type II and Type III beads from separate independent bead applicators, unless otherwise approved by the Engineer.

4. CONSTRUCTION

Place markings before opening to traffic unless short-term or work zone markings are allowed.

4.1. **General**. Obtain approval for the sequence of work and estimated daily production. Minimize interference to roadway operations when placing markings on roadways open to traffic. Use traffic control as shown on the plans or as approved. Protect all markings placed under open-traffic conditions from traffic damage and disfigurement.

Establish guides to mark the lateral location of pavement markings as shown on the plans or as directed, and have guide locations verified. Use material for guides that will not leave a permanent mark on the roadway.

Apply markings on pavement that is completely dry and passes the following tests:

- Type I Marking Application—Place a sample of Type I marking material on a piece of tarpaper placed on the pavement. Allow the material to cool to ambient temperature, and then inspect the underside of the tarpaper in contact with the pavement. Pavement will be considered dry if there is no condensation on the tarpaper.
- Type II Marking Application—Place a 1-sq. ft. piece of clear plastic on the pavement, and weight down the edges. The pavement is considered dry if, when inspected after 15 min., no condensation has occurred on the underside of the plastic.

Apply markings:

- that meet the requirements of Tex-828-B,

- that meet minimum retroreflectivity requirements when specified on the plans (applies to Type I markings only),
- using widths and colors shown on the plans,
- at locations shown on the plans,
- in proper alignment with the guides without deviating from the alignment more than 1 in. per 200 ft. of roadway or more than 2 in. maximum,
- without abrupt deviations,
- free of blisters and with no more than 5% by area of holes or voids,
- with uniform cross-section, density and thickness,
- with clean and reasonably square ends,
- that are retroreflectorized with drop-on glass beads, and
- using personnel skilled and experienced with installation of pavement markings.

Remove all applied markings that are not in alignment or sequence as stated on the plans, or in the specifications, at the Contractor's expense in accordance with Item 677, "Eliminating Existing Pavement Markings and Markers," except for measurement and payment.

4.2. **Surface Preparation**. Prepare surfaces in accordance with this Section unless otherwise shown on the plans.

4.2.1. **Cleaning for New Asphalt Surfaces and Retracing of All Surfaces**. Air blast or broom the pavement surface for new asphalt surfaces (less than 3 years old) and for retracing of all surfaces to remove loose material, unless otherwise shown on the plans. A sealer for Type I markings is not required unless otherwise shown on the plans.

4.2.2. **Cleaning for Old Asphalt and Concrete Surfaces (Excludes Retracing)**. Clean old asphalt surfaces (more than 3 years old) and all concrete surfaces in accordance with Item 678, "Pavement Surface Preparation for Markings," to remove curing membrane, dirt, grease, loose and flaking existing construction markings, and other forms of contamination.

4.2.3. **Sealer for Type I Markings**. Apply a pavement sealer to old asphalt surfaces (more than 3 years old) and to all concrete surfaces before placing Type I markings on locations that do not have existing markings, unless otherwise approved. The pavement sealer may be either a Type II marking or an acrylic or epoxy sealer as recommended by the Type I marking manufacturer unless otherwise shown on the plans. Follow the manufacturer's directions for application of acrylic or epoxy sealers. Clean sealer that becomes dirty after placement by washing or in accordance with Section 666.4.2.1., "Cleaning for New Asphalt Surfaces and Retracing of All Surfaces," as directed. Place the sealer in the same configuration and color (unless clear) as the Type I markings unless otherwise shown on the plans.

4.3. **Application**. Apply markings during good weather unless otherwise directed. If markings are placed at Contractor option when inclement weather is impending and the markings are damaged by subsequent precipitation, the Contractor is responsible for all required replacement costs.

4.3.1. **Type I Markings**. Place the Type I marking after the sealer cures. Apply within the temperature limits recommended by the material manufacturer. Flush the spray head if spray application operations cease for 5 min or longer by spraying marking material into a pan or similar container until the material being applied is at the recommended temperature.

Apply on clean, dry pavements passing the moisture test described in Section 666.4.1., "General," and with a surface temperature above 50°F when measured in accordance with Tex-829-B.

4.3.1.1. **Non-Profile Pavement Markings**. Apply Type I non-profile markings with a minimum thickness of:

- 0.100 in. (100 mils) for new markings and retracing water-based markings on surface treatments involving Item 316, "Seal Coat,"

- 0.060 in. (60 mils) for retracing on thermoplastic pavement markings, or
- 0.090 in. (90 mils) for all other Type I markings.

The maximum thickness for Type I non-profile markings is 0.180 in. (180 mils). Measure thickness for markings in accordance with Tex-854-B using the tape method.

4.3.1.2. **Profile Pavement Markings**. Apply Type I profile markings with a minimum thickness of:

- 0.060 in. (60 mil) for edgeline markings, or
- 0.090 in. (90 mil) for gore and centerline/no-passing barrier line markings.

In addition, at a longitudinal spacing indicated on the plans, the markings must be profiled in a vertical manner such that the profile is transverse to the longitudinal marking direction. The profile must not be less than 0.30 in. (300 mil) nor greater than 0.50 in. (500 mil) in height when measured above the normal top surface plane of the roadway. The transverse width of the profile must not be less than 3.25 in., and the longitudinal width not less than 1 in., when measured at the top surface plane of the profile bar. The profile may be either a 1 or 2 transverse bar profile. When the 2 transverse bar profile is used, the spacing between the bases of the profile bars must not exceed 0.50 in. The above transverse bar width is for each 4 in. of line width.

4.3.2. **Type II Markings**. Apply on surfaces with a minimum surface temperature of 50°F. Apply at least 20 gal. per mile on concrete and asphalt surfaces and at least 22 gal. per mile on surface treatments for a solid 4-in. line. Adjust application rates proportionally for other widths. When Type II markings are used as a sealer for Type I markings, apply at least 15 gal. per mile using Type II drop-on beads.

4.3.3. **Bead Coverage**. Provide a uniform distribution of beads across the surface of the stripe for Type I and Type II markings, with 40% to 60% bead embedment.

4.4. **Retroreflectivity Requirements**. When specified on the plans, Type I markings must meet the following minimum retroreflectivity values for edgeline markings, centerline or no passing barrier-line, and lane lines when measured any time after 3 days, but not later than 10 days after application:

- White markings: 250 millicandelas per square meter per lux (mcd/m^2/lx)
- Yellow markings: 175 mcd/m^2/lx

4.5. **Retroreflectivity Measurements**. Use a mobile retroreflectometer for projects requiring minimum retroreflectivity requirements to measure retroreflectivity for Contracts totaling more than 200,000 ft. of pavement markings, unless otherwise shown on the plans. For Contracts with less than 200,000 ft. of pavement markings or Contracts with callout work, mobile or portable retroreflectometers may be used at the Contractor's discretion.

4.5.1. **Mobile Retroreflectometer Measurements**. Provide mobile measurements averages for every 0.1 miles unless otherwise specified or approved. Take measurements on each section of roadway for each series of markings (i.e., edgeline, center skip line, each line of a double line, etc.) and for each direction of traffic flow. Measure each line in both directions for centerlines on two-way roadways (i.e., measure both double solid lines in both directions and measure all center skip lines in both directions). Furnish measurements in compliance with Special Specification, "Mobile Retroreflectivity Data Collection for Pavement Markings," unless otherwise approved. The Engineer may require an occasional field comparison check with a portable retroreflectometer meeting the requirements listed above to ensure accuracy. Use all equipment in accordance with the manufacturer's recommendations and directions. Inform the Engineer at least 24 hr. before taking any measurements.

A marking meets the retroreflectivity requirements if:

- the combined average retroreflectivity measurement for a one-mile segment meets the minimum retroreflectivity values specified, and
- no more than 30% of the retroreflectivity measurement values are below the minimum retroreflectivity requirements value within the one-mile segment.

The Engineer may accept failing one-mile segments if no more than 20% of the retroreflectivity measurements within that mile segment are below the minimum retroreflectivity requirement value.

The one-mile segment will start from the beginning of the data collection and end after a mile worth of measurements have been taken; each subsequent mile of measurements will be a new segment. Centerlines with 2 stripes (either solid or broken) will result in 2 miles of data for each mile segment. Each centerline stripe must be tested for compliance as a stand-alone stripe.

Restripe at the Contractor's expense with a minimum of 0.060 in. (60 mils) of Type I marking if the marking fails retroreflectivity requirements. Take measurements every 0.1 miles a minimum of 10 days after this second application within that mile segment for that series of markings.

If the markings do not meet minimum retroreflectivity after 10 days of this second application, the Engineer may require removal of all existing markings, a new application as initially specified, and a repeat of the application process until minimum retroreflectivity requirements are met.

4.5.2. **Portable Retroreflectometer Measurements**. Take a minimum of 20 measurements for each 1-mi. section of roadway for each series of markings (i.e., edgeline, center skip line, each line of a double line, etc.) and direction of traffic flow when using a portable reflectometer. Measure each line in both directions for centerlines on two-way roadways (i.e., measure both double solid lines in both directions and measure all center skip lines in both directions). The spacing between each measurement must be at least 100 ft. The Engineer may decrease the mileage frequency for measurements if the previous measurements provide satisfactory results. The Engineer may require the original number of measurements if concerns arise.

Restripe once at the Contractor's expense with a minimum of 0.060 in. (60 mils) of Type I marking material if the average of these measurements fails. Take a minimum of 10 more measurements after 10 days of this second application within that mile segment for that series of markings. Restripe again at the Contractor's expense with a minimum of 0.060 in. (60 mils) of Type I marking material if the average of these measurements fall below the minimum retroreflectivity requirements. If the markings do not meet minimum retroreflectivity after this third application, the Engineer may require removal of all existing markings, a new application as initially specified, and a repeat of the application process until minimum retroreflectivity requirements are met.

4.5.3. **Traffic Control**. Provide traffic control, as required, when taking retroreflectivity measurements after marking application. On low volume roadways (as defined on the plans), refer to the figure, “Temporary Road Closure” in Part 6 of the *Texas Manual on Uniform Traffic Control Devices* for the minimum traffic control requirements. For all other roadways, the minimum traffic control requirements will be as shown on the Traffic Control Plan (TCP) standard sheets TCP (3-1) and TCP (3-2). The lead vehicle will not be required on divided highways. The TCP and traffic control devices must meet the requirements listed in Item 502, “Barricades, Signs, and Traffic Handling.” Time restrictions that apply during striping application will also apply during the retroreflectivity inspections except when using the mobile retroreflectometer unless otherwise shown on the plans or approved.

4.6. **Performance Period**. All markings must meet the requirements of this specification for at least 30 calendar days after installation. Unless otherwise directed, remove pavement markings that fail to meet requirements, and replace at the Contractor’s expense. Replace failing markings within 30 days of notification. All replacement markings must also meet all requirements of this Item for a minimum of 30 calendar days after installation.

5. MEASUREMENT

This Item will be measured by the foot; by each word, symbol, or shape; or by any other unit shown on the plans. Each stripe will be measured separately.

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.

Acrylic or epoxy sealer, or Type II markings when used as a sealer for Type I markings, will be measured by the foot; by each word, symbol, or shape; or by any other unit shown on the plans.

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 “Pavement Sealer” of the size specified, “Retroreflectorized Pavement Markings” of the type and color specified and the shape, width, size, and thickness specified as applicable, “Retroreflectorized Pavement Markings with Retroreflective Requirements” of the types, colors, sizes, widths, and thicknesses specified or “Retroreflectorized Profile Pavement Markings” of the various types, colors, shapes, sizes, and widths specified.

This price is full compensation for application of pavement markings, materials, equipment, labor, tools, and incidentals.

Surface preparation of new concrete and asphalt concrete pavements more than 3 years old, where no stripe exists, will be paid for under Item 678, “Pavement Surface Preparation for Markings.” Surface preparation of all other asphalt and old concrete pavement, except for sealing, will not be paid for directly but is subsidiary to this Item.

Work zone pavement markings (Type II, paint and beads) used as a sealer for Type I markings (thermoplastic) will be paid for under Item 662, “Work Zone Pavement Markings.”

If the Engineer requires that markings be placed in inclement weather, repair or replacement of markings damaged by the inclement weather will be paid for in addition to the original plans quantity.

Item 668
Prefabricated Pavement Markings

1. DESCRIPTION

Furnish and place retroreflectorized or non-reflectorized (contrast) prefabricated pavement markings.

2. MATERIALS

Furnish prefabricated pavement marking materials in accordance with DMS-8240, "Permanent Prefabricated Pavement Markings."

Furnish prefabricated pavement marking materials used for contrast markings in accordance with DMS-8240, "Permanent Prefabricated Pavement Markings," with the exception that the color requirement for the black contrast portion does not have to meet the color requirements specified for white or yellow markings. Store all materials in a weatherproof enclosure and prevent damage during storage.

3. CONSTRUCTION

3.1. **General**. Obtain approval for the sequence of work and estimated daily production. Remove all waste generated from the jobsite before the end of each working day.

Establish guides to mark the lateral location of pavement markings as shown on the plans or as directed, and have guide locations verified. Use guide material that will not leave a permanent mark on the roadway.

Place pavement markings in alignment with the guides without deviating from the alignment more than 1 in. per 200 ft. of roadway or more than 2 in. maximum and with no abrupt deviations.

3.2. **Placement Limitations**. Do not place Type B pavement-marking materials between September 30 and March 1 unless otherwise directed.

3.2.1. **Moisture**. Apply material to pavement that is completely dry. Pavement will be considered dry if, on a sunny day after 15 min., no condensation occurs on the underside of a 1-sq. ft. piece of clear plastic that has been placed on the pavement and weighted on the edges.

3.2.2. **Temperature**. Follow pavement and ambient air temperature requirements recommended by the material manufacturer. Do not place material when the pavement temperature is below 60°F or above 120°F if the material manufacturer does not establish temperature requirements.

3.3. **Dimensions**. Place markings in accordance with the color, length, width, shape, and configuration shown on the plans. Locate alignment as shown on the plans or as directed.

3.4. **Methods**. Place all materials in accordance with the material manufacturer's instructions, as well as the surface condition, moisture and temperature requirements of this Item, unless otherwise directed.

3.5. **Surface Preparation**. Prepare surface by any approved cleaning method that effectively removes contaminants, loose materials, and conditions deleterious to proper adhesion. Abrasive or water-blast cleaning is not required unless shown on the plans. Blast clean, when required, in accordance with Item 678, "Pavement Surface Preparation for Markings." Prepare surfaces further after cleaning by sealing or priming as recommended by the pavement-marking material manufacturer or as directed. Use adhesive, when required, of the type and quality recommended by the pavement-marking material manufacturer. Do not clean concrete pavement surfaces by grinding.

3.6. **Performance Requirements**.

3.6.1. **Adhesion**. Ensure markings do not lift, shift, smear, spread, flow, or tear by traffic action.

3.6.2. **Appearance**. Ensure markings present a neat, uniform appearance that is free of excessive adhesive, ragged edges, and irregular lines or contours.

3.6.3. **Visibility**. Ensure markings have uniform and distinctive retroreflectance when inspected in accordance with Tex-828-B.

3.7. **Performance Period**. All markings must meet the requirements of this Item for at least 30 calendar days after installation. Remove and replace all pavement markings that fail to meet requirements at the Contractor's expense unless otherwise directed. Replace failing markings within 30 days of notification. All replacement markings must also meet all requirements of this Item for a minimum of 30 calendar days after installation.

4. MEASUREMENT

This Item will be measured by the foot or by each word, shape, or symbol.

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.

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 "Prefabricated Pavement Markings" of the type and color specified and the shape, width, and size specified as applicable. This price is full compensation for cleaning the pavement by any means other than required abrasive or water-blast cleaning or milling; furnishing and placing materials; and equipment, labor, tools, and incidentals.

Abrasive or water-blast cleaning and milling, when shown on the plans, will be paid for under Item 678, "Pavement Surface Preparation for Markings."

Item 672
Raised Pavement Markers

1. DESCRIPTION

Furnish and install raised pavement markers (RPMs).

2. MATERIALS

2.1. **Markers**. Furnish RPMs in accordance with the following Department Material Specifications:

- **Reflectorized Pavement Markers**. DMS-4200, "Pavement Markers (Reflectorized)," types I-A, I-C, I-R, II-A-A, and II-C- R.
- **Traffic Buttons**. DMS-4300, "Traffic Buttons," types I-A, I-C, I-R, II-A-A, II-C- R, W, Y and B. Round or oval unless otherwise specified on the plans.
- **Plowable Reflectorized Pavement Markers**. DMS-4210, "Snowplowable Pavement Markers," types I-A, I-C, I-R, II-A-A, and II-C- R.

The following are descriptions for each type of RPM:

- **Type I-A**. The approach face must retro-reflect amber light. The body, other than the retro-reflective face, must be yellow.
- **Type I-C**. The approach face must retro-reflect white light. The body, other than the retro-reflective face, must be white or silver-white.
- **Type I-R**. The trailing face must retro-reflect red light. The body, other than the retro-reflective face, must be white or silver-white, except for I-R plowable markers which may be black.
- **Type II-A-A**. The 2 retro-reflective faces (approach and trailing) must retro-reflect amber light. The body, other than the retro-reflective faces, must be yellow.
- **Type II-C-R**. Contain 2 retro-reflective faces with an approach face that must retro-reflect white light and a trailing face that must retro-reflect red light. The body, other than the retro-reflective faces, must be white or silver-white.
- **Type W**. Must have a white body and no reflective faces.
- **Type Y**. Must have a yellow body and no reflective faces.
- **Type B**. Must have a black body and no reflective faces.

2.2. **Adhesives**. Furnish adhesives that conform to the following requirements:

- DMS-6100, "Epoxies and Adhesives," Type II—Traffic Marker Adhesives.
- DMS-6130, "Bituminous Adhesive for Pavement Markers."
- The Contractor may propose alternate adhesive materials for consideration and approval.

2.3. **Sampling**. The Engineer will sample in accordance with Tex-729-I.

3. CONSTRUCTION

Remove existing RPMs in accordance with Item 677, "Eliminating Existing Pavement Markings and Markers," except for measurement and payment. Furnish RPMs for each class from the same manufacturer. Prepare all surfaces in accordance with Item 678, "Pavement Surface Preparation for Markings," when shown on the plans. Ensure the bond surfaces are free of dirt, curing compound, grease, oil, moisture, loose or unsound pavement markings, and any other material that would adversely affect the adhesive bond.

Establish pavement marking guides to mark the lateral location of RPMs as shown on the plans and as directed. Do not make permanent marks on the roadway for the guides.

Place RPMs in proper alignment with the guides. Acceptable placement deviations are shown on the plans.

Remove RPMs placed out of alignment or sequence, as shown on the plans or stated in this specification, at Contractor's expense, in accordance with Item 677, "Eliminating Existing Pavement Markings and Markers" (except for measurement and payment).

Use the following adhesive materials for placement of reflectorized pavement markers, and traffic buttons unless otherwise shown on the plans:

- standard or flexible bituminous adhesive for applications on bituminous pavements, and
- epoxy adhesive or flexible bituminous adhesive for applications on hydraulic cement concrete pavements.

Use epoxy adhesive for plowable reflectorized pavement markers.

Apply enough adhesives to:

- ensure that 100% of the bonding area of RPMs is in contact with the adhesive, and
- ensure that RPMs, except for plowable markers, are seated on a continuous layer of adhesive and not in contact with the pavement surface.

Apply adhesives in accordance with manufacturer's recommendations unless otherwise required by this Article. Apply bituminous adhesive only when pavement temperature and RPM temperature are 40°F or higher. Do not heat bituminous adhesive above 400°F. Machine agitate bituminous adhesive continuously before application to ensure even heat distribution.

Machine-mix epoxy adhesive. Apply epoxy adhesive only when pavement temperature is 50°F or higher.

Furnish RPMs free of rust, scale, dirt, oil, grease, moisture, and contaminants that might adversely affect the adhesive bond.

Place RPMs immediately after the adhesive is applied and ensure proper bonding. Do not use adhesives or any other material that impairs the functional retro-reflectivity of the RPMs.

Provide a 30-day performance period that begins the day following written acceptance for each separate location. The date of written acceptance will be the last calendar day of each month for the RPMs installed that month for the completed separate project locations. This written acceptance does not constitute final acceptance.

Replace all missing, broken or non-reflective RPMs. Visual evaluations will be used for these determinations. Upon request, the Engineer will allow a Contractor representative to accompany the Engineer on these evaluations.

The Engineer may exclude RPMs from the replacement provisions of the performance, provided the Engineer determines the failure is a result of causes other than defective material or inadequate installation procedures. Examples of outside causes are extreme wear at intersections, damage by snow or ice removal, and pavement failure.

Replace all missing or non-reflective RPMs identified during the performance period within 30 days after notification. The end of the performance period does not relieve the Contractor from the performance deficiencies requiring corrective action identified during the performance period.

4. MEASUREMENT

This Item will be measured by each RPM.

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 are required.

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 "Reflectorized Pavement Marker," "Traffic Button," or "Plowable Reflectorized Pavement Marker" of the types specified. This price is full compensation for removing existing markers; furnishing and installing RPMs; and materials, equipment, labor, tools, and incidentals.

No additional payment will be made for replacement of RPMs failing to meet the performance requirements.

Item 677
Eliminating Existing Pavement Markings and Markers

1. DESCRIPTION

Eliminate existing pavement markings and raised pavement markers (RPMs).

2. MATERIALS

Furnish surface treatment materials in accordance with the following Items:

- Item 300, “Asphalts, Oils, and Emulsions”
- Item 302, “Aggregates for Surface Treatments”
- Item 316, “Seal Coat”

Use approved patching materials for repairing damaged surfaces.

Use a commercial abrasive blasting medium capable of producing the specified surface cleanliness. Use potable water when water is required.

3. EQUIPMENT

Furnish and maintain equipment in good working condition. Use moisture and oil traps in air compression equipment to remove all contaminants from the blasting air and prevent the deposition of moisture, oil, or other contaminants on the roadway surface.

4. CONSTRUCTION

Eliminate existing pavement markings and markers on both concrete and asphaltic surfaces in such a manner that color and texture contrast of the pavement surface will be held to a minimum. Remove all markings and markers with minimal damage to the roadway to the satisfaction of the Engineer. Repair damage to asphaltic surfaces, such as spalling, shelling, etc., greater than 1/4 in. deep resulting from the removal of pavement markings and markers. Dispose of markers in accordance with federal, state, and local regulations. Use any of the following methods unless otherwise shown on the plans:

4.1. **Surface Treatment Method**. Apply surface treatment material at rates shown on the plans, or as directed. Place a surface treatment a minimum of 2 ft. wide to cover the existing marking. Place a surface treatment, thin overlay, or microsurfacing a minimum of one lane in width in areas where directional changes of traffic are involved or other areas as directed.

4.2. **Burn Method**. Use an approved burning method. For thermoplastic pavement markings or prefabricated pavement markings, heat may be applied to remove the bulk of the marking material before blast cleaning. When using heat, avoid spalling pavement surfaces. Sweeping or light blast cleaning may be used to remove minor residue.

4.3. **Blasting Method**. Use a blasting method such as water blasting, abrasive blasting, water abrasive blasting, shot blasting, slurry blasting, water-injected abrasive blasting, or brush blasting as approved. Remove pavement markings on concrete surfaces by a blasting method.

4.4. **Mechanical Method**. Use any mechanical method except grinding. Flail milling is acceptable in the removal of markings on asphalt and concrete surfaces.

5. MEASUREMENT

This Item will be measured by each word, symbol, or shape eliminated; by the foot of marking eliminated; or by any other unit shown on the plans.

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.

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 “Eliminating Existing Pavement Markings and Markers” of the type and width as applicable. This price is full compensation for the elimination method used and materials, equipment, tools, labor, and incidentals. Removal of RPMs will not be paid for directly but will be subsidiary to the pertinent bid items.

Item 678
Pavement Surface Preparation for Markings

1. DESCRIPTION

Prepare pavement surface areas before placement of pavement markings and raised pavement markers (RPMs). Item 677, "Eliminating Existing Pavement Markings and Markers," governs removal of existing markings.

2. MATERIALS

Use a commercial abrasive blasting medium capable of producing the specified surface cleanliness. Use potable water, when water is required.

3. EQUIPMENT

Furnish and maintain equipment in good working condition. Use moisture and oil traps in air compression equipment to remove all contaminants from the blasting air and prevent the deposition of moisture, oil, or other contaminants on the roadway surface.

4. CONSTRUCTION

Prepare enough pavement surface for the pavement markings or RPMs shown on the plans. Remove all contamination and loose material. Avoid damaging the pavement surface. Remove loose and flaking material when existing pavement markings are present. Approved pavement surface preparation methods are sweeping, air blasting, flail milling, and blast cleaning unless otherwise specified on the plans.

Air blast concrete pavement surfaces, in addition to the above, after the removal of contamination or existing material and just before placing the stripe. Perform air blasting with a compressor capable of generating compressed air at a minimum of 150 cu. ft. per minute and 100 psi using 5/16 in. or larger hosing.

Contaminants up to 0.5 sq. in. may remain if they are not removed by the following test, performed just before application of markings:

- **Step 1**. Air blast the surface to be tested, to simulate blasting during application of markings.
- **Step 2**. Firmly press a 10-in. long, 2-in. wide strip of monofilament tape onto the surface, leaving approximately 2 in. free.
- **Step 3**. Grasp the free end and remove the tape with a sharp pull.

5. MEASUREMENT

This Item will be measured by the foot for each width specified; by each word, shape, or symbol; or by any other unit except lump sum.

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.

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 "Pavement Surface Preparation for Markings" of the type and width as applicable. This price is full compensation for the cleaning method used, materials, equipment, labor, tools, and incidentals.

Item 685
Roadside Flashing Beacon Assemblies

1. DESCRIPTION

- **Installation**. Furnish, fabricate, and erect roadside flashing beacon assemblies.
- **Relocation**. Remove and relocate existing roadside flashing beacon assemblies.
- **Removal**. Remove existing roadside flashing beacon assemblies.

2. MATERIALS

Furnish new materials in accordance with the following Items and details shown on the plans:

- Item 441, "Steel Structures"
- Item 442, "Metal for Structures"
- Item 445, "Galvanizing"
- Item 449, "Anchor Bolts"
- Item 656, "Foundations for Traffic Control Devices"

Provide prequalified flasher controller assemblies from the Department's MPL in accordance with DMS-11160, "Flasher Controller Assembly."

Provide prequalified pedestal pole bases from the Department's MPL in accordance with DMS-11140, "Pedestal Pole Base."

When shown on the plans, provide prequalified solar powered flasher controller assemblies from the Department's MPL in accordance with DMS-11150, "Solar Power Flasher Controller Assembly."

3. CONSTRUCTION

Install foundations for installation and relocation in accordance with Item 656, "Foundations for Traffic Control Devices."

3.1. **Fabrication**. Provide poles and bases in accordance with Item 687, "Pedestal Pole Assemblies." Provide mild steel anchor bolts in accordance with Item 449, "Anchor Bolts." Use galvanized bolts, nuts, and washers.

3.2. **Galvanizing**. Galvanize all fabricated parts in accordance with Item 445, "Galvanizing." Repair galvanizing for any steel part or member damaged in assembly, transit, or erection, or any steel part or member welded after galvanizing, in accordance with Section 445.3.5., "Repairs."

3.3. **Installation**. Install roadside flashing beacon assemblies at the locations shown on the plans or as directed. Stake the assembly locations for verification by the Engineer unless otherwise shown on the plans.

Install pole, breakaway base, connectors, wiring, signal beacons, sign, and foundation as shown on the plans, or as directed. Install the flasher controller assembly on the electrical service pole. Install watertight breakaway electrical fuse holders in all line and neutral conductors at the breakaway base.

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

Install solar panels, batteries, and battery box (when required) as shown on the plans or as directed.

3.4. **Relocation**. Disconnect and isolate the electrical power supply before removal of the assembly. Remove existing assembly as directed. Salvage existing components such as sign, beacons, pole, and base unless otherwise directed. Repair or replace lost or damaged components as directed.

Relocate existing assembly to the location shown on the plans or as directed. Install existing assembly at new foundations in accordance with Section 685.3.3., "Installation." Remove existing foundations in accordance with Section 685.3.5., "Removal." Accept ownership of unsalvageable materials and dispose of in accordance with federal, state, and local regulations.

3.5. **Removal**. Disconnect and isolate existing electrical power supplies before removal of the assembly. Remove existing sign panel, beacons, pole, and base from existing assembly. Store items to be reused or salvaged without damaging. Store sign panels above the ground in a vertical position at locations shown on the plans or as directed. Accept ownership of unsalvageable materials and dispose of in accordance with federal, state, and local regulations.

Remove abandoned foundations, including steel, to 2 ft. below the finished grade unless otherwise shown on the plans. Backfill with material equal in composition and density to the surrounding area, and replace any surfacing, such as asphalt pavement or concrete riprap, with like material to equivalent condition.

4. MEASUREMENT

This Item will be measured by each installed, relocated, or removed roadside flashing beacon assembly.

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 Roadside Flashing Beacon Assemblies," "Install Roadside Flashing Beacon Assemblies (Solar Powered)," "Relocate Roadside Flashing Beacon Assemblies," "Relocate Roadside Flashing Beacon Assemblies (Solar Powered)," "Remove Roadside Flashing Beacon Assemblies," or "Remove Roadside Flashing Beacon Assemblies (Solar Powered)." The Department will pay for electrical energy consumed by the roadside flashing beacon.

New conduit will be paid for under Item 618, "Conduit," except for conduit in the foundation and within 6 in. of the foundation. New electrical conductors will be paid for under Item 620, "Electrical Conductors." New tray cable will be paid for under Item 621, "Tray Cable." New duct cable will be paid for under Item 622, "Duct Cable." New ground boxes will be paid for under Item 624, "Ground Boxes." New electrical services will be paid for under Item 628, "Electrical Services." New signs will be paid for under Item 636, "Signs." New signal heads will be paid for under Item 682, "Vehicle and Pedestrian Signal Heads." New traffic signal cable will be paid for under Item 684, "Traffic Signal Cables."

5.1. **Installation**. This price is full compensation for furnishing, fabricating, galvanizing, assembling, and erecting the roadside flashing beacon assemblies including poles and bases; solar power flashing controller assemblies including battery box (when required); foundations; conduit in the foundation and within 6 in.of the foundation; furnishing and placing anchor bolts, nuts, washers, and templates; controller; and materials, equipment, labor, tools, and incidentals.

5.2. **Relocation**. This price is full compensation for removing the roadside flashing beacon assemblies; removing battery box (when required); removing existing foundations; installing new foundations; installing new conduit in the foundation and within 6 in.of the foundation; furnishing, fabricating, and installing any new components as required and replacing the assembly on its new foundations with all manipulations and electrical work; controller; salvaging; disposal of unsalvageable materials; loading and hauling; and materials, equipment, labor, tools, and incidentals.

5.3. **Removal**. This price is full compensation for removing the various roadside flashing beacon assemblies components; removing the foundations; storing the components to be reused or salvaged; disposal of unsalvageable materials; backfilling and surface placement; loading and hauling; and materials, equipment, tools, labor, and incidentals.

Item 735
Debris Removal

1. DESCRIPTION

Remove and dispose of debris discarded or deposited on or adjacent to the pavement. Debris includes all objects not part of the highway facility, such as dead animals, tires, tire fragments, wood, furniture, mattresses, household appliances, and scrap metal.

2. EQUIPMENT

Provide highly visible omni-directional flashing warning lights on work vehicles. Provide equipment that prevents the accumulated debris from being strewn along the roadway during transport.

3. WORK METHODS

Remove debris at locations shown on the plans. Notify the Department for removal of hazardous materials. Dispose of debris off the right of way in accordance with applicable federal, state, and local regulations.

3.1. **Center Medians and Mainlanes**. Remove and dispose of debris from the main travel lanes, paved medians, paved shoulders, and an additional 5 ft. adjacent to the pavement, unless otherwise shown on the plans.

3.2. **Frontage Roads**. Remove and dispose of debris from frontage roads, shoulders, U-turn lanes, and intersecting streets to the right of way, including turn lanes, underpasses and overpasses, and an additional 5 ft. adjacent to the pavement, unless otherwise shown on the plans.

3.3. **Entrance and Exit Ramps**. Remove and dispose of debris from ramps, shoulders, and an additional 5 ft. adjacent to the pavement, unless otherwise shown on the plans.

3.4. **High Occupancy Vehicle (HOV) Lane.** Remove and dispose of debris from HOV lanes including HOV ramps. The HOV lanes are defined as:

3.4.1. **Barrier-Separated Contraflow Lane.** Barrier-separated contraflow lane(s) is defined as a lane enclosed by two physical barriers.

3.4.2. **Buffer-Separated Concurrent Flow Lane.** Buffer-separated concurrent flow lane is separated from general purpose lanes by a striped buffer zone and is defined as the left or inner most lane identified by signing and diamond symbols on the pavement.

3.5. **Direct Connector Ramp Debris Removal.** Remove and dispose of debris from the shoulders and paved gutters of direct connector ramp.

3.6. **Spot Debris Removal**. Work requests are made on a callout basis. Remove and dispose of debris as directed. Begin removing debris within 3 hr. of notification, unless otherwise shown on the plans.

4. MEASUREMENT

This Item will be measured as follows:

4.1. **Center Medians and Mainlanes, Frontage Roads, and Entrance and Exit Ramps**. By the cycle or right of way centerline mile. A right of way centerline mile is defined as the distance from beginning reference marker location to ending reference marker location, regardless of the number of roadbeds.

4.2. **HOV Lane Debris Removal.** By the cycle or HOV lane centerline miles. HOV lane centerline mile is defined as the distance measured along each HOV lane regardless of the number of lanes.

4.3. **Direct Connector Ramp Debris Removal.** By the cycle or direct connector ramp centerline mile. A direct connector centerline mile is defined as the distance measured along each direct connector regardless of the number of lanes.

4.4. **Spot Debris Removal**. By the roadbed mile. The minimum quantity per callout is 1 roadbed mile, unless otherwise shown on the plans.

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 prices bid for "Debris Removal" of the type and cycle location specified. This price is full compensation for collecting, hauling and disposing of debris, and for equipment, labor, materials, tools, and incidentals. Traffic control will not be paid for directly but will be subsidiary to this Item, unless otherwise shown on the plans.

Debris removal in buffer-separated concurrent flow lanes is considered subsidiary to debris removal in center medians and mainlanes, unless otherwise shown on the plans.

Debris removal required for work orders issued under Item 734, "Litter Removal," or Item 738, "Cleaning and Sweeping Highways," will be subsidiary to that Item unless otherwise shown on the plans.

Item 738
Cleaning and Sweeping Highways

1. DESCRIPTION

Clean and sweep highway facilities.

2. EQUIPMENT

Furnish equipment and tools capable of dislodging crusted debris from road surfaces, removing and collecting materials from roadway. Provide highly visible omni-directional flashing warning lights on work vehicles. Furnish equipment with a water tank and adequate spray assemblies for dust control, and a dirt hopper with enough capacity to allow progress with minimum interference to traffic. Provide other types of cleaning and sweeping equipment, including hand tools, when required.

3. WORK METHODS

Completely remove debris from pavement surfaces and other areas designated on the plans, such as all sides of raised pavement markers, barrier drain slots, slotted drains, inlet openings, attenuators, and guardrails. Notify the Department for removal of hazardous materials. Debris is defined as dirt and other objects not part of the highway facility including dead animals, tires, tire fragments, wood, furniture, mattresses, household appliances, and scrap metal. Collect the debris and dispose of it off the right of way in accordance with federal, state, and local regulations. Ensure debris is not swept or blown onto traffic lanes. The types of cleaning and sweeping are as follows:

3.1. **Center Median Cleaning and Sweeping**. Clean and sweep the paved center medians or left-paved shoulders and left-paved gutters.

3.2. **Outside Mainlane Cleaning and Sweeping**. Clean and sweep the outside lanes or right-paved shoulders and right paved gutters. Clean and sweep intersecting streets to the right of way line.

3.3. **Frontage Road Cleaning and Sweeping**. Clean and sweep the right- and left-paved shoulders and paved gutters on all frontage roads. Clean and sweep U-turn lanes and intersecting streets to the right of way line, including turn lanes, underpasses, and overpasses.

3.4. **Entrance and Exit Ramp Cleaning and Sweeping**. Clean and sweep right- and left-paved shoulders and paved gutters of ramps.

3.5. **Direct Connector Cleaning and Sweeping.** Clean and sweep the right and left paved shoulders and paved gutters of direct connectors.

3.6. **HOV Lane Cleaning and Sweeping.** Clean and sweep HOV lanes, bridges and ramps.

3.7. **Aggregate Removal**. Clean and remove aggregate from designated areas following adverse weather conditions.

3.8. **Spot Sweeping**. Work requests are made on a callout basis. Clean and sweep roadways in designated areas. Begin sweeping within 3 hr. of notification, unless otherwise shown on the plans.

3.9. **Handwork**. Clean and sweep areas as shown on the plans or as directed.

4. MEASUREMENT

Right of way centerline mile is defined as the distance measured from the beginning point to the ending point shown on the plans and is measured once regardless of the number of lanes or roadbeds.

Ramp centerline mile is defined as the distance measured along each ramp regardless of the number of lanes. A roadbed mile is defined as the distance along each roadbed regardless of the number of lanes.

HOV lane centerline mile is defined as the distance measured along each HOV lane regardless of the number of lanes. A direct connector centerline mile is defined as the distance measured along each direct connector regardless of the number of lanes.

Types of cleaning and sweeping will be measured as follows:

4.1. **Center Median**. By the cycle or right of way centerline mile.

4.2. **Outside Mainlane**. By the cycle or right of way centerline mile.

4.3. **Frontage Road**. By the cycle or right of way centerline mile.

4.4. **Entrance and Exit Ramp**. By the cycle or ramp centerline mile.

4.5. **HOV Lane Cleaning and Sweeping.** By the cycle or HOV lane centerline mile.

4.6. **Direct Connector Cleaning and Sweeping.** By the cycle or direct connector centerline mile.

4.7. **Aggregate Removal**. By the roadbed mile.

4.8. **Spot**. By the roadbed mile. The minimum quantity per callout is 1 roadbed mile, unless otherwise shown on the plans.

4.9. **Handwork**. By the square yard.

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 "Cleaning and Sweeping" of the type and cycle location specified. This price is full compensation for cleaning, sweeping, collecting, hauling and disposing of debris, and for equipment, labor, materials, tools, and incidentals.

When work requests include multiple bid items and overlap occurs, the measurement and payment priority will be determined by the order shown in "Measurement."

Cleaning of items such as raised pavement markers, barrier drain slots, slotted drains, inlet openings, and areas adjacent to attenuator and guardrail supports will not be paid for directly but will be subsidiary to this Item unless otherwise shown on the plans.

Item 780
Concrete Crack Repair

1. DESCRIPTION

Repair cracks in concrete members by epoxy injection, gravity filling, routing and sealing, or surface sealing.

2. MATERIALS

Provide materials in accordance with the Department's *Concrete Repair Manual*. Select a pre-approved material meeting the requirements of the applicable DMS when available.

3. WORK METHODS

Follow the procedures outlined in the Department's *Concrete Repair Manual*. Submit alternate procedures to the Engineer for approval before proceeding with repair work.

The manual includes the following categories of concrete crack repair:

- Pressure-Injected Epoxy,
- Gravity-Fed Sealant,
- Routing and Sealing, and
- Surface Sealing.

4. MEASUREMENT

This Item will be measured by the foot of exterior crack length, injected gallon, square footage for flood coats, or lump sum.

5. PAYMENT

The work performed and the materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Concrete Crack Repair" of the type specified. This price is full compensation for furnishing and installing all repair materials, equipment, labor, and incidentals.

Item 785
Bridge Joint Repair or Replacement

1. DESCRIPTION

Repair or replace damaged bridge joint as shown on the plans.

2. MATERIALS

Provide materials conforming to the pertinent requirements of the following Items except as shown on the plans:

- Item 429, “Concrete Structure Repair,”
- Item 449, “Anchor Bolts,”
- Item 454, “Bridge Expansion Joints,” and
- DMS-6100, “Epoxies and Adhesives.”

Submit information on pre-packaged repair materials and concrete mix design a minimum of 10 days before beginning work.

3. EQUIPMENT

Provide equipment in accordance with Item 429, “Concrete Structure Repair,” and Item 448, “Structural Field Welding.”

4. WORK METHODS

Obtain approval for all materials and work methods before beginning work.

Repair damaged bridge joints as shown on the plans. Perform the work in accordance with Item 429, “Concrete Structure Repair,” Item 438, “Cleaning and Sealing Joints,” Item 448, “Structural Field Welding,” and Item 454, “Bridge Expansion Joints,” as directed. Provide certified welder when shown on the plans.

Remove concrete and steel sections to limits shown on the plans and as approved when damage extends past specified regions. Repair concrete and steel members damaged by the Contractor beyond limits shown at no additional cost. Contain concrete during removal from falling onto lower roadway or into waterway. Remove existing joint and seal. Ensure prestressed concrete deck panel is not damaged during concrete removal. Clean and extend existing reinforcing steel and replace any damaged steel or add additional steel as shown on the plans.

Examine existing steel joint, finger plate, armor plate, or sliding plate to determine if the items are salvageable. Reinstall anchor bolts, anchor studs, and other steel attachments if loose and in accordance with the plans.

Install replacement joint system as shown on the plans. Set joint opening as shown on the plans and as directed. Restore concrete under and around joint flush with top of riding surface. Cure repaired concrete a minimum of 4 days, unless directed otherwise.

Prepare and seal joint opening. Match existing joint seal type unless shown otherwise. Splice new joint seal to existing joint seal when required in accordance with manufacturer’s recommended practices to obtain adequate bond between existing seal and new seal.

5. MEASUREMENT

This Item will be measured by the foot of joint repaired, per side of joint opening, and by the foot of joint replaced.

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 "Bridge Joint Repair" and "Bridge Joint Replacement" of the type identified. This price is full compensation for removing existing joint and seal; breaking back and repairing concrete damaged for joint removal and replacement; removing and replacing additional concrete as shown on the plans; furnishing and placing all materials, cleaning and sealing the joints, disposal of all materials removed, additional sealant required to extend into concrete rail or curb, additional material that may be required due to existing asphalt and concrete removal being more than estimate on the plans; and for all labor, tools, equipment, and incidentals necessary to complete the work.

Special Specification 3037
High Friction Surface Treatment

1. DESCRIPTION

Construct a High Friction Surface Treatment (HFST) consisting of one application of a single layer of a binder resin system covered with a single layer of calcined bauxite aggregate. The binder resin system is typically comprised of an epoxy or polymer resin. HFST is only applicable for spot treatments on horizontal curves, approaches to intersections, and ramps to restore or enhance the frictional properties of the roadway to improve safety and reduce the frequency of vehicular crashes.

2. MATERIALS

2.1. **General**. Furnish uncontaminated materials of uniform quality that meet the requirements of the plans and specifications. Notify the Engineer of all material sources. Notify the Engineer before changing any material source or formulation. The Engineer may sample and test project materials at any time during the project to verify specification compliance.

2.2. **Binder Resin System.** Provide a binder resin system, meeting the requirements below, recommended by the manufacturer as suitable for use on the intended pavement surface and for the potential range of atmospheric exposure.

Table 1
Binder Resin System Requirements

Property	Test Method	Requirement	
		Minimum	Maximum
Viscosity, poises	Tex-614-J	7	30
Gel Time, minutes	Tex-614-J	10	-
Ultimate Tensile Strength, psi	Tex-618-J	2,500	5,000
Elongation at Break Point, %	Tex-618-J	30	70
Durometer Hardness (shore D)	ASTM D-2240	60	80
Minimum Compressive Strength*: 3 Hours 7 Days	Tex-614-J	 1,000 5,000	 - -
Cure Rate (dry through time), hours	ASTM D-1640	-	3
Water Absorption, %	ASTM D-570	-	1
Tensile Bond	Tex-614-J	250 psi min or 100% substrate failure	

*specimen size 1"X1"

Formulate the binder such that at temperatures above 77°F, the gel time should be more than 5 minutes and at temperatures below 77°F the cure time is no greater than 3 hours. Provide a table of gel time and cure rate at temperatures from 55°F to 105°F at 10°F increments to indicate the gel and cure expected at application temperature.

2.3. **Aggregate**. Furnish calcined bauxite aggregate meeting the requirements listed in Table 2. Provide aggregate that is clean, dry, and free from foreign matter.

Table 2
Aggregate Requirements

Property	Test Method	Requirement
Aggregate Gradation: % Passing the #4 sieve Minimum % Passing the #6 sieve Maximum % Passing the #16 sieve	Tex-401-A	 100 95 5
Los Angeles (LA) Abrasion, % Max (Loss after 100 Revolutions)	Tex-410-A	10
Magnesium Sulfate Soundness, 5 Cycles, % Maximum (Stockpile Gradation)	Tex-411-A	30
Acid Insoluble, % Minimum	Tex-612-J	90
Aluminum Oxide Content, % Minimum	ASTM C-25	87

2.4. **Materials Packaging.**

2.4.1. **Binder Resin System Packaging.**

Supply resin system components in well-sealed containers clearly labeled as to the type material and the ratio of the components to be mixed by volume. Include any special mixing instructions.

On the label, show resin or hardener components, brand name, name of manufacturer, lot or batch number, temperature range for storage, expiration date, and quantity in the container. Also include any caution warnings for use.

2.4.2. **Aggregate Packaging.**

Furnish aggregates in appropriate packaging that protects the aggregate from contamination, rain, and moisture and is clearly labeled with the name of the manufacturer and location of processing

2.5. **Acceptance of Materials.** Provide an independent laboratory test report for the polymer binder and calcined bauxite aggregate that show these materials meet the requirements listed in Tables 1 and 2. Submit documentation of the in-place friction characteristics (minimum 65 FN40R in accordance with ASTM E274) of aggregate bonded to a vehicular bearing surface using the polymer binder. Supply a sample of the resin binder or components lot/batch and calcined bauxite aggregate to the Engineer prior to the start of placement to allow for testing and reporting. When the system materials are part of the National Transportation Product Evaluation Program (NTPEP) and show satisfactory performance, testing by the Engineer is not required.

3. QUALITY CONTROL PLAN (QCP)

Develop and follow the QCP in detail. Obtain prior approval for changes to the QCP made during the project. The Engineer may suspend operations if the Contractor fails to comply with the QCP.

Submit a written QCP before the pre-construction or pre-paving meeting. Receive approval of the QCP before beginning production. Include the following information in the QCP:

- Names and contact information for key personnel, project superintendent, and lead technician responsible for field quality control sampling and testing;
- Equipment calibration records for metering devices and application monitoring devices;
- Procedures for storage of materials for both stockpiled and onsite;
- Procedures for blending of materials;
- Procedures for preparation of surface before treatment;
- Procedures for placement for the full roadway condition to include mainlanes, shoulders, and miscellaneous areas without overlapping;
- Procedures for cleaning equipment in the field;

- Monitoring and recording ambient and surface temperatures and conditions;
- Recording of quantities of materials installed;
- Procedures for curing of HFST; and
- Corrective actions to address irregularities or unsatisfactory final surface.

4. STAFFING REQUIREMENTS

The manufacturer of the binder resin system is required to have a representative at the pre-construction and/or pre-paving meeting and at the construction site to provide recommendations and technical assistance to the Engineer and Contractor personnel before placement of the HFST and as necessary during the surface preparation, material placement and during any necessary corrective actions. The manufacturer's representative must be an employee of the binder resin manufacturing company.

5. EQUIPMENT

5.1. **Cleaning.** Use equipment for surface cleaning operations where applicable, in accordance with Item 738, "Cleaning and Sweeping Highways." Use other cleaning equipment required in this specification.

5.2. **Automated Application.** If used or required, provide automated or semi-automated application equipment to apply resin binder and automated equipment to apply aggregate.

5.3. Automated resin binder equipment must:

- utilize continuous pumping and portioning devices that blend the polymer binder within a controlled system
- be capable of producing real time data flow showing the volume of binder resin and the average binder resin mil thickness throughout the application width.
- be capable of applying the minimum binder spread rate per the recommendation from the manufacturer of the binder resin system and according to this specification; and
- be capable of applying up to a continuous 12 ft. width application.

5.4. Semi-Automated resin binder equipment must:

- utilize continuous pumping and portioning devices that blend the polymer binder within a controlled system;
- be capable of applying a binder volume to achieve the minimum binder spread rate per the recommendation from the manufacturer of the binder resin system and according to this specification;
- may use manual means to spread binder to the binder spread rate per the recommendation from the manufacturer of the binder resin system and according to this specification, such as using serrated edge squeegees and workers wearing spiked shoes; and
- be capable of applying up to a 12 ft. width application.

5.5. Automated aggregate spreader equipment must:

- be capable of applying the calcined bauxite aggregate while the resin is fluid and before the gel time of the binder applied on the pavement;
- apply a quantity of aggregate to completely saturate the surface such that no uncovered binder is visible; and
- apply up to a continuous 12 ft. width application.

5.6. The binder and aggregate application may be applied by one integrated vehicle.

6. CONSTRUCTION

6.1. **General.** Place materials only when weather conditions and moisture conditions of the roadway surface are suitable as determined by the Engineer. Do not apply the binder resin on a wet surface, when the surface temperature is below 55°F, or the ambient temperature is above 105°F unless the manufacturer provides test data demonstrating gel time of 5 minutes minimum and a cure rate (dry through time) of 3 hr. maximum when cured at representative temperatures. Do not apply the polymer binder when the anticipated weather conditions would prevent the proper application of the surface treatment as determined by the manufacturer's representative. Do not place the HFST with visible moisture on the prepared surface. Test for moisture in the pavement by taping an 18"x18" plastic sheet to the pavement per ASTM D4263. A 2-hour minimum test duration is allowed in lieu of the 16 hours specified in ASTM D4263. Perform the plastic sheet test only when surface temperatures and ambient conditions are within the established parameters for application of the overlay system. In the event of rain, allow the pavement to air dry for a minimum of 24 hr. prior to performing the plastic sheet test.

6.2. **Surface Preparation.** When applying HFST on new pavements or over areas that have been recently crack sealed, wait a minimum of 30 days after placement of the underlying surface or crack sealant. All patching materials for concrete surface shall be free of Magnesium Phosphate.

Protect utilities, drainage structures, curbs, and any other structure within or adjacent to the treatment location against the application of the surface treatment materials. Adequately cover expansion joints and deck drains prior to applying HFST. Remove covering from all covered areas immediately before the binder resin starts to cure.

Cover and protect existing pavement markings that are adjacent to the application surfaces as directed. Remove existing or temporary pavement markings that are within the surface application area in accordance with Item 677, "Eliminating Existing Pavement Markings and Markers," except for Measurement and Payment.

Clean asphalt pavement surfaces using mechanical sweepers and high pressure air wash with sufficient oil traps. Mechanically sweep all surfaces to remove dirt, loose aggregate, debris, and deleterious material.

Clean concrete pavement surfaces by shot blasting and vacuum sweeping. Shot blast all surfaces to remove all curing compounds, loosely bonded mortar, surface carbonation, and deleterious material. Ensure the prepared surface complies with the International Concrete Repair Institute (ICRI) standard for surface roughness CSP 5.

For pavement surfaces contaminated with oils, greases, or other deleterious materials not removed by the surface preparation, wash with a mild detergent solution, rinse with clean potable water, and dry using a hot compressed air lance.

Treat cracks greater than 1/4 in. in width and depth with the mixed binder resin system, unless otherwise directed by the Engineer. Installation of the HFST may proceed immediately after treating these cracks with no minimum amount of time required for waiting. Do not treat cracks less than 1/4" in. in width and depth before placement of the HFST.

When the Engineer allows the application equipment to drive on the pavement after surface preparation, provide precautions acceptable to the Engineer to ensure that the surface will not become contaminated. If traffic is allowed on the surface after surface preparation, a visual inspection by the manufacturer and Engineer must be performed to determine if additional surface preparation is needed before applying material.

6.3. **Control Strip.** When directed by the Engineer, construct a control strip of HFST before starting any production work. The control strip is required to meet the following:

- Included in the measurement and payment per requirements in Sections 7 and 8;
- Minimum width of 12 ft. and length of 20 ft. within the limits of the project; and
- Constructed using the same equipment as the anticipated production work.

Replicate field conditions, including ambient and surface temperatures, anticipated for the production work. Demonstrate surface preparation requirements. Remove pavement markers within the area to receive HFST, for the lane and length involved, prior to placing polymer binder resin system. Document the settings on the applicator equipment, initial quantities of polymer binder resin and calcined bauxite aggregate, and unused quantities of resin and aggregate remaining in the applicator equipment after applying the HFST. Determine the dry through time for the polymer binder resin system.

6.4. **Mixing and Application Methods.** Use a manual mixing and application, automated or semi-automated application process to apply the HFST. Construct a control strip to demonstrate the proposed application process. Use an automated process for areas greater than 250 square yards.

6.4.1. **Automated Application.** Use automated or semi-automated application equipment to apply the resin binder and calcined bauxite aggregate in one continuous application pass.

Blend and mix the binder resin using the ratio specified by the manufacturer (+/- 2% by volume) and continuously apply once blended. Ensure mixing is complete and does not entrain air in the binder. Apply the binder resin to a uniform thickness of 50-65 mils (25-32 ft2/gal).

Apply the calcined bauxite to the binder on the road surface while the resin is fluid and before the gel time of the binder applied on the pavement.. Apply aggregate with a method approved by the binder resin manufacturer and the Engineer with equipment capable of dispensing the aggregate onto the roadway in a uniform manner. Apply a quantity of aggregate to completely saturate the surface such that no uncovered binder is visible. Do not compact or force embedment of the calcined bauxite with a roller of any type or size after placement.

Do not allow the mixed material to separate, cure, dry, be exposed or otherwise harden in such a way as to impair retention and bonding of the high friction surfacing aggregate. Remove and replace any section of wet, uncured resin that is contacted by foreign material or becomes contaminated at the contractor's expense.

6.4.2. **Manual Mixing and Application.** Manual mixing and application is allowed for individual areas less than 250 square yards. Manually-mix the binder resin in accordance with the manufacturer's recommendations. Apply the binder resin to a uniform thickness of 50-65 mils (25-32 ft^2/gal).

Uniformly spread the binder resin onto the surface using a serrated edge squeegee and wearing spiked shoes. Minimize walking, standing, or any form of contact or contamination of the wet uncured binder resin system prior to the application of the calcined bauxite.

Immediately apply the calcined bauxite aggregate on the binder on the road surface by broadcasting until refusal while the resin is fluid and before the gel time of the binder applied on the pavement. Apply a quantity of aggregate to completely saturate the surface such that no uncovered binder is visible. Do not compact or force embedment of the calcined bauxite with a roller of any type or size after placement.

6.5. **Placement.** On roadways with higher degrees of transverse cross slope or longitudinal grade, maintain the specified thickness of the HFST throughout the entire area to be treated (ensure thickness is maintained on the high side of slope/grade). Ensure proper precautions are in place to keep the base binder resin from running across or down the pavement to the low point of the roadway.

6.6. **Cleanup.** Remove excess and loose aggregate from the traveled way and shoulders by street sweeping. When directed by the Engineer, sweep a second time after 24 hr. to one week of application. Recovered calcined bauxite aggregate may be reused only once. Verify the recovered aggregate is clean, uncontaminated, and dry prior to any reuse. Recovered aggregate must be blended with new aggregate at a rate of 2:1 (two parts of new bauxite to one part recovered bauxite). Provide a written record of the recovered aggregate and mark containers holding the recovered aggregate as "Recovered Bauxite" with the project number.

6.7. **Curing.** Cure the HFST in accordance with the manufacturer's recommendation. Protect treated surface from traffic until the area has cured.

7. MEASUREMENT

High Friction Surface Treatment will be measured by the square yard of completed and accepted work. No deduction will be made for the areas occupied by manholes, inlets, drainage structures, pavement markings, or by any public utility appurtenances within the area.

This is a plans quantity 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.

8. 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 "High Friction Surface Treatment." This price is full compensation for surface preparation, joint and crack treatment, furnishing, preparing, hauling and placing materials including epoxy binder, removing existing pavement markings and excess aggregate as needed, and for labor, tools, equipment, and incidentals.

Special Specification 4002
Elastomeric Bearing Pads

1. DESCRIPTION

Replace elastomeric bridge bearings.

2. MATERIALS

Furnish elastomeric bearings meeting the requirements of Item 434, "Bridge Bearings." Fabricate new bearings to the indicated dimensions.

3. CONSTRUCTION

Raise spans as necessary to replace the indicated bearings in conformance with Item 495, "Raising Existing Structures." Individual girders may be raised if approved and if no damage occurs to the slab or adjacent girders.

Remove indicated bearings. Do not use flame-cutting techniques to remove bearing pads.

Clean existing bearing seats and the bearing contact area on the bottoms of concrete girders by steam cleaning to remove all wax residue and other deleterious materials. After steam cleaning, use abrasive blasting to roughen the bearing contact surfaces on the bearing seats and the bottoms of concrete girders. Use oil-free compressed air for final cleaning to remove all loose material from bearing contact areas.

Repair spalls at bearing areas as indicated in accordance with Item 429, "Concrete Structure Repair." Restore or reconstruct damaged bearing seats as necessary to ensure they meet the requirements of Section 420.4.9, "Treatment and Finishing of Horizontal Surfaces."

If indicated, construct pedestals in accordance with the pertinent Items and the details shown on the plans.

Place new bearing pads after all bearing seat or spall repair materials have attained a compressive strength of 3,000 psi. Do not use dry cement powder under the new bearings.

Completely remove all hardware or appurtenances used to raise the spans or girders. Repair any damage resulting from the lifting operation at no expense to the Department.

4. MEASUREMENT

This Item will be measured by each bearing replaced.

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 "Replacing Elastomeric Bearing Pads." This price is full compensation for raising the spans or girders, removing the original bearing pads, cleaning and restoring the bearing contact areas, furnishing and installing new bearing pads, equipment, labor, shoring, falsework, tools, and incidentals. The work performed to raise the spans or girders in accordance with Item 495, "Raising Existing Structures," will not be paid for directly but is considered subsidiary to this Item. Concrete spall repairs will be measured and paid for in accordance with Item 429, "Concrete Structure Repair."

Pedestals will be paid for in accordance with Item 420, “Concrete Substructures,” or Item 442, “Metal for Structures,” as indicated.

Special Specification 6056

Preformed In-Lane (Transverse)/Centerline Rumble Strips

1. DESCRIPTION

Furnish and install preformed in-lane (transverse) or preformed centerline rumble strips as shown on the plans.

2. MATERIALS

Provide rumble strips from manufacturers prequalified by the Department. The Traffic Operations Division maintains a list of prequalified rumble strip manufacturers.

3. CONSTRUCTION

Install the in-lane (transverse) rumble strips in locations shown in the plans. Install centerline rumble strips in the gaps between broken centerline pavement marking stripes as shown in the plans. Install the rumble strips in accordance to manufacturer's recommendations.

4. MEASUREMENT

This Item will be measured transversely by the foot across the roadway on which the rumble strip is installed. Measurement shall include all strips of materials placed across the roadway surface.

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 "Preformed In-Lane (Transverse) Rumble Strips" or "Preformed Centerline Rumble Strips." This price shall be full compensation for all labor, equipment, tools and incidentals necessary to complete the work.

Special Specification 6376
Solar Powered Driver Feedback Speed Sign Assembly (Ped Pole Mount)

1. DESCRIPTION

Furnishing and install Solar Powered Driver Feedback Speed Sign Assembly. The Driver Feedback Speed Sign (DFSS) is a dynamic numeric sign that gives motorists real time feedback as to their vehicle's speed via radar speed detection.

2. MATERIALS

2.1. **DFSS Display**

2.1.1. **(1)** Furnish displays that flash the LEDs, when the detected vehicle speed exceeds the posted speed. The display shall be selectable and capable of displaying “Your Speed” or “Slow Down” in two lines of 4 in. high letters (Min). Furnish yellow numeric displays that utilize replaceable modules, capable of displaying the approaching vehicle speed. The sign back ground shall be black. Numeric speed display characters shall be 10 inches in height. (Min) Supply either a clear or a tinted UV-stabilized acrylic on the DFSS Display non-reflective surface.

2.1.2. **(2)** Provide LEDs that have 1.4 candela luminous intensity and 22 degrees viewing angle. The lighting system will be controlled automatically by a photocell, utilizing pulse width modulation. This system adjusts the lighting intensity, for daytime, nighttime and adverse weather conditions.

2.1.3. **(3)** Furnish (DFSS) signs that have fluorescent yellow reflective pixels and have a viewing angle of at least 160° in daylight. At night, when measured at 1.0° observation in accordance with ASTM E 810, the pixels will have a minimum viewing angle of 30° and a minimum Coefficient of Retroreflection of 8.0 cd/lx/m2 at 45° entrance.

2.1.4 **(4)** Provide display pixels that are impregnated with Poly Tetra Fluoroethylene (PTFE). The self-lubricating, PTFE impregnated bearing will have a Mean Time Before Failure (MTBF) of 300 million cycles @ 4 Hz, which equates to 200,000 hours (typical message cycle of 3 seconds, 2 seconds ON; 1 second OFF/CHANGE).

2.2. **Solar Generator / Photovoltaic Modules / Power / Battery / Wiring / Housing**

The system shall be capable of operating the unit without the aid of recharging from an external power source.

2.2.1. **Solar Generator.** The Driver Feedback Speed Sign Assembly shall be sized for 24/7/365 solar operation. Size the system solar generator to provide an array-to-load ratio of 1:1 or greater. Provide a system-average state of charge 90% or greater throughout the entire year. The system-loss of-load probability must remain 0% throughout the entire year.

Provide a system-sizing report detailing the photovoltaic array, battery bank, array-to-load ratio analysis, system availability analysis, battery state-of-charge report, battery depth of discharge, for the County of Texas noted in the plans.

2.2.2. **Photovoltaic Modules.** The photovoltaic (PV) module must provide 12V DC and be capable of recharging the system to full capacity in 3 hr. ± 0.5 hr. during optimum sun conditions. Supply industrial-grade,

polycrystalline-type solar modules. Consumer grade modules are not acceptable. Solar modules must have a power output rating of ± 5% or better. Ensure PV modules are available to the Department in a graduated product line from 40to 120Wper module. Each solar module .regardless of wattage must share common mounting holes for mountings so that a single mounting structure that will accommodate the entire module line. Incorporate a 6-in.square polycrystalline cell and at least 2 bypass diodes installed at the factory into each solar module. Construct PV module with a low-iron tempered glass surface and an industrial grade anodized aluminum frame that completely surrounds and seals the module laminate. Ensure construction is consistent with the demands of installation near humid salt air environments. Provide an ultraviolet resistant, weather proof junction box providing wire termination for up to No. 8 AWG wiring with the PV module.

Design and construct the photovoltaic module mounting assembly of galvanized steel (ASTM A-153 Class A) or aluminum. The mounting assembly must provide a means of securely attaching the PV module frame to a pole ranging from a minimum 2.875 inch outside diameter steel or aluminum pole at a permanent angle of 45 degrees to 50 degrees. Provide at stainless steel bolts, lock washers, and hex head nuts with the mounting assembly to secure the PV module to the frame. Provide a mounting assembly capable of 360 degree horizontal orientation with a means of locking the bracket at an angular position about the pole.

The PV wiring harness must not exceed 2% total voltage drop between the PV solar module and the charge control circuit.

2.2.3. **Battery.** Provide group-27gel batteries specified in the system sizing report. Use valve-regulated, gelled-electrolyte batteries rated for a minimum of 2000 cycles with 10% capacity withdraw. Provide 12 V DC batteries. Use lead-calcium for the plate alloy. Use a T881-type terminal element post designed for 1/4-in. bolt termination. Use a polypropylene container or cover. The gelled electrolyte must contain sulfuric acid, fumed silica, pure de-mineralized and de-ionized water, and a phosphoric-acid additive. Provide a spill-proof gel cell battery to allow installation in any position. Size the batteries to allow 12 days autonomy. Depth of Discharge (DOD) for the system must not exceed 80%.

Provide an on-board, solid state charge-control unit to ensure proper charging on the system battery bank. Incorporate a blocking diode for reverse-current protection of the charging circuit. Provide an LED or LCD to indicate solar-panel charging.

Provide a user-adjustable low-voltage disconnect circuit in the controller. This circuit must disconnect the battery bank when the battery voltage reaches a voltage deemed critical by the manufacturer of the batteries. Provide an LED indication for the low-voltage disconnect circuit.

2.2.4. **Wiring.** Supply a colored-coded wiring harness. Use connectors to terminate the harness wiring to all components of the assembly. Supply male and female connectors for each harness. Use housing chassis tie-downs on the wiring harnesses and protect with spiral tubing. Provide a total voltage drop no greater than 5% of any branch of the wiring harness.

2.2.5. **Housing.** Provide a cast-aluminum housing or aluminum housing with a minimum thickness of 1/8 inch. Size the housing to provide adequate space for the control electronics, radar unit, and the required number of batteries. Install rubber mats in the bottom of the housing. Provide a gasket between the door and housing. Supply a stainless- steel door hinge and a stainless-steel hinge pin. Spot weld the hinge pin at the top of the hinge. Weather proof the housing to prevent the entry of water. Seal un-welded seams with a clear or aluminum colored weather-seal compound.

Provide vent openings in the housing to allow adequate convection cooling of the electronic component and prevention of accumulation of gasses. Design and locate vents to prevent the entry of water. Screen the vents to minimize the infiltration of dust and insects. Screen material must have openings no larger than 0.0125 square inches.

Provide a lock with a metal keyhole cover as an integral part of each door. Provide three (3) keys with each unit. Provide tamper-resistant exposed hardware including screws, bolts, rivets, hubs, etc. Provide two (2) ¾ inch stainless steel brackets for strap-type mounting to a pole ranging from a minimum 2.875 inch outside diameter steel or aluminum pole.

The housing shall have a back panel inside the housing. Mount wiring and accessory equipment on the back panel. Equip the housing with a barrier terminal block with double (8-32x 5/16 inch) binder head screws terminals or larger.

2.3. **DFSS Controller**

2.3.1. **(1)** Furnish a radar controller that is FCC compliant K band radar microwave vehicle detector integrated in the sign with a factory preset range of 600 feet. Speed range of at least 5 to 99 miles per hour. 12 degree bean accuracy +/-1 unit of measure. The unit shall be field replaceable. The radar generated speed shall be displayed on the DFSS sign. The radar controller shall be able to be field calibrated. The trigger speed shall be adjustable from the DFSS control.

2.3.2. **(2)** The controller must incorporate automatic luminosity control to suit ambient light conditions. Calibrate the night-dim level to reduce the power of the LED Lamps when the ambient light levels are five (5) foot-candles or less.

2.3.3. **(3)** Furnish controllers that are capable of providing local control of the unit. The local control will be a lockable, vandal resistant. The controller shall provide: on/off toggle control of the sign, and a changeable message that reads: “Your Speed” or “Slow Down” which shall be toggle switchable or keypad adjustable.

2.3.4. **(4)** Supply a solid-state flasher that operates on 12 V DC with no electro-mechanical devices. The solid-state flasher must provide a flash rate in accordance with the Texas MUTCD standards.

2.3.5. **(5)** Covert Mode / Data Logging. The DFSS Controller shall be capable of working in covert mode to obtain speed data while the display remains blank. The DFSS controller shall be equipped with data logging collection. The log shall track the date, time, speed of vehicles and store the data on a standard SD Card that is capable of being opened by Microsoft Excel. Other file formats or Bluetooth communication upon approval of the project engineer.

2.3.6. **Shop Drawings.** Shop drawings and product documentation shall be submitted to the project engineer prior to ordering materials and equipment. The project engineer will review the submittal and notify the contractor of the project engineer comments concerning the shop drawings.

3. DOCUMENTATION REQUIREMENTS

Supply two (2) copies of the following documentation with each solar-powered flashing assembly: complete and accurate schematic diagrams, complete parts list, including names of vendors for parts not identified by universal part numbers, full report on system analysis, including all manufacturing supporting documentation, complete user’s manual for the system.

4. CONSTRUCTION

Install DFSS unit, flashing beacon assemblies, sign and solar powered panel assembly as shown on the plans, or as directed.

5. MEASUREMENT

This Item will be measured by each complete system which includes but is not limited to all DFSS Control equipment, DFSS flashing display assemblies, and solar powered panel assembly; furnished, installed, make fully operational, and tested in accordance with these specifications.

6. WARRANTY

All equipment must have no less than 95% of the manufacturer's standard warranty remaining on the date that the contractor submits equipment invoices for payment. The Department will not accept any equipment with less than 95% of its warranty remaining.

Provide warranties in accordance with the following table, “Required Warranties":

REQUIRED WARRANTIES

Item	Warranty (Type & Time Period)
Photovoltaic Module	Limited – 10 years
Batteries	Prorated – 5 years
Display Unit	Limited – 5 years
Radar Unit	Limited – 5 years
All other Equipment	Limited – 3 years

7. 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 “Driver Feedback Speed Sign Assembly (solar)” each. This price will be full compensation for furnishing, fabricating, galvanizing, assembling, and erecting the roadside DFSS Control Unit, DFSS Sign Assembly, and solar powered panel assemblies; Pedestal Pole Assemblies and foundations pole per the plans, furnishing and placing anchor bolts, nuts, washers, and templates; controllers; all material testing and equipment; and equipment hardware; operational software package(s); supplies; support; personnel training; shop drawings; documentation; incidental materials, and for all tools and labor.