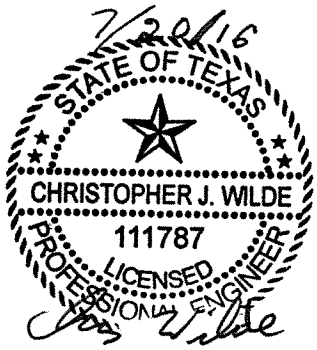
**TECHNICAL SPECIFICATIONS**

**CITY OF SAN ANGELO, TEXAS**

**Martin Luther King Drive Street Improvements**

**TxDOT CSJ No. 0907-24-043**
**Federal Project No. STP 2014(091)TE**
**City of San Angelo Bid No. ES-03-16**




**JULY, 2016**

**Prepared by:**

**58 Buick Street**
**San Angelo, TX 76901**
**325.947.1555**
***www.ksaeng.com***

**TBPE Firm Registration No. F-1356**

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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.

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 110
# Excavation

## 1. DESCRIPTION

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

## 2. CONSTRUCTION

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

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

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

2.1. Rock Cuts. Excavate to finish subgrade. Manipulate and compact subgrade in accordance with Section 132.3.4., "Compaction Methods," unless excavation is to clean homogenous rock at finish subgrade elevation. Use approved embankment material compacted in accordance with Section 132.3.4., "Compaction Methods," to replace undercut material at no additional cost if excavation extends below finish subgrade.

2.2. Earth Cuts. Excavate to finish subgrade. Scarify subgrade to a uniform depth at least 6 in. below finish subgrade elevation in areas where base or pavement structure will be placed on subgrade. Manipulate and compact subgrade in accordance with Section 132.3.4., "Compaction Methods."

Take corrective measures as directed if unsuitable material is encountered below subgrade elevations.

2.3. Subgrade Tolerances. Excavate to within 1/2 in. in cross-section and 1/2 in. in 16 ft. measured longitudinally for turnkey construction. Excavate to within 0.1 ft. in cross-section and 0.1 ft. in 16 ft. measured longitudinally for staged construction.

## 3. MEASUREMENT

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

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

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

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

## 4. PAYMENT

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

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

Drying required deeper than 6 in. below subgrade elevation will be paid for in accordance with Article 9.7., "Payment for Extra Work and Force Account Method." Excavation and replacement of unsuitable material below subgrade elevations will be performed and paid for in accordance with the applicable bid items. However, if Item 132, "Embankment," is not included in the Contract, payment for replacement of unsuitable material will be paid for in accordance with Article 9.7., "Payment for Extra Work and Force Account Method."

When a slide not due to the Contractor's negligence or operation occurs, payments for removal and disposal of the slide material will be in accordance with Article 9.7., "Payment for Extra Work and Force Account Method." Excavation in backfill areas of retaining walls will not be measured or paid for directly but will be subsidiary to pertinent Items.

# Item 112
# Subgrade Widening

## 1. DESCRIPTION

Widen the existing subgrade in accordance with the typical sections.

## 2. MATERIALS

Furnish water in accordance with Article 204.2., "Materials."

## 3. CONSTRUCTION

3.1. Preparation of Embankment. Scarify to a depth of at least 6 in. into existing adjacent embankment slopes before fill is placed.

3.2. Pavement Structure Removal. Remove material along the edge of the existing pavement. Provide a smooth vertical cut unless otherwise shown on the plans. Conform to the typical sections for the limits of removal unless directed otherwise. Accept ownership of excess material not used in the construction of the subgrade widening. Dispose of excess material in accordance with federal, state, and local regulations.

3.3. Widening. Remove material in cut sections, and move to fill sections within the project. Use material from cut sections for embankment. Place the material in fill sections in successive lifts to the line and grades shown on the typical sections. Provide additional embankment in accordance with the applicable bid item or Article 9.7., "Payment for Extra Work and Force Account Method," if all excavation has been performed and additional embankment is required to complete the work.

3.4. Compaction. Compact the widened subgrade in accordance with Article 132.3., "Construction."

## 4. MEASUREMENT

This Item will be measured by the 100-ft. station along the baseline of each roadbed.

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 "Subgrade Widening (Ordinary Compaction)" or "Subgrade Widening (Density Control)." This price is full compensation for excavation; hauling of embankment material from cuts to fills; finishing of the subgrade widening; hauling and disposing of excess excavated material; furnishing and operating equipment; scarifying; shaping; and labor, fuel, materials, tools, and incidentals.

No payment will be made for thickness or width exceeding that shown on the typical sections. "Sprinkling" and "Rolling" will not be paid for directly but will be considered subsidiary to this Item.

Corrections of unstable areas in the widened subgrade will be at the Contractor's expense. In a cut section, work involved in removing and replacing unsuitable material encountered below the finished subgrade will be

paid for as specified under Item 110, “Excavation,” when included; otherwise it will be paid for under Article 9.7., “Payment for Extra Work and Force Account Method.”

# Item 132
# Embankment

## 1. DESCRIPTION

Furnish, place, and compact materials for construction of roadways, embankments, levees, dikes, or any designated section of the roadway where additional material is required.

## 2. MATERIALS

Furnish approved material capable of forming a stable embankment from required excavation in the areas shown on the plans or from sources outside the right of way. Provide one or more of the following types as shown on the plans:

- Type A. Granular material that is free from vegetation or other objectionable material and meets the requirements of Table 1.

Table 1
Testing Requirements

| Property | Test Method | Specification Limit |
|---|---|---|
| Liquid limit | Tex-104-E | ≤ 45 |
| Plasticity index (PI) | Tex-106-E | ≤ 15 |
| Bar linear shrinkage | Tex-107-E | ≥ 2 |

Perform the Linear Shrinkage test only as indicated in Tex-104-E.

- Type B. Materials such as rock, loam, clay, or other approved materials.
- Type C. Material meeting the specification requirements shown on the plans. Type C may be further designated as Type C1, C2, etc.
- Type D. Material from required excavation areas shown on the plans.

Meet the requirements of the pertinent retaining wall Items for retaining wall backfill material.

## 3. CONSTRUCTION

Meet the requirements of Item 7, "Legal Relations and Responsibilities," when off right of way sources are used. Notify the Engineer before opening a material source to allow for required testing. Complete preparation of the right of way in accordance with Item 100, "Preparing Right of Way," for areas to receive embankment.

Backfill tree-stump holes or other minor excavations with approved material and tamp. Restore the ground surface, including any material disked loose or washed out, to its original slope. Compact the ground surface by sprinkling in accordance with Item 204, "Sprinkling," and by rolling using equipment complying with Item 210, "Rolling," when directed.

Scarify and loosen the unpaved surface areas, except rock, to a depth of at least 6 in. unless otherwise shown on the plans. Bench slopes before placing material. Begin placement of material at the toe of slopes. Do not place trees, stumps, roots, vegetation, or other objectionable material in the embankment. Simultaneously recompact scarified material with the placed embankment material. Do not exceed the layer depth specified in Section 132.3.4., "Compaction Methods."

Construct embankments to the grade and sections shown on the plans. Construct the embankment in layers approximately parallel to the finished grade for the full width of the individual roadway cross-sections unless

otherwise shown on the plans. Ensure that each section of the embankment conforms to the detailed sections or slopes. Maintain the finished section, density, and grade until the project is accepted.

3.1. Earth Embankments. Earth embankment is mainly composed of material other than rock. Construct embankments in successive layers, evenly distributing materials in lengths suited for sprinkling and rolling.

Treat material with calcium-based additives in accordance with Section 260.2.3., "Flexible Base," when required. Obtain approval to incorporate rock and broken concrete produced by the construction project in the lower layers of the embankment. Place the rock and concrete outside the limits of the completed roadbed when the size of approved rock or broken concrete exceeds the layer thickness requirements in Section 132.3.4., "Compaction Methods." Cut and remove all exposed reinforcing steel from the broken concrete.

Move the material dumped in piles or windrows by blading or by similar methods and incorporate it into uniform layers. Featheredge or mix abutting layers of dissimilar material for at least 100 ft. to ensure there are no abrupt changes in the material. Break down clods or lumps of material and mix embankment until a uniform material is attained.

Apply water free of industrial wastes and other objectionable matter to achieve the uniform moisture content specified for compaction.

Roll and sprinkle each embankment layer in accordance with Section 132.3.4.1., "Ordinary Compaction," when ordinary compaction is specified. Compact the layer to the required density in accordance with Section 132.3.4.2., "Density Control," when density control is specified.

3.2. Rock Embankments. Rock embankment is mainly composed of rock. Construct rock embankments in successive layers for the full width of the roadway cross-section with a depth of 18 in. or less. Increase the layer depth for large rock sizes as approved. Do not exceed a depth of 2-1/2 ft. in any case. Fill voids created by the large stone matrix with smaller stones during the placement and filling operations.

Ensure the depth of the embankment layer is greater than the maximum dimension of any rock. Do not place rock greater than 2 ft. in its maximum dimension, unless otherwise approved. Construct the final layer with graded material so that the density and uniformity is in accordance with Section 132.3.4., "Compaction Methods." Break up exposed oversized material as approved.

Roll and sprinkle each embankment layer in accordance with Section 132.3.4.1., "Ordinary Compaction," when ordinary compaction is specified. Compact each layer to the required density in accordance with Section 132.3.4.2., "Density Control," when density control is specified. Proof-roll each rock layer as directed, where density testing is not possible, in accordance with Item 216, "Proof Rolling," to ensure proper compaction.

3.3. Embankments Adjacent to Culverts and Bridges. Compact embankments adjacent to culverts and bridges in accordance with Item 400, "Excavation and Backfill for Structures."

3.4. Compaction Methods. Begin rolling longitudinally at the sides and proceed toward the center, overlapping on successive trips by at least 1/2 the width of the roller. Begin rolling at the lower side and progress toward the high side on super elevated curves. Alternate roller trips to attain slightly different lengths. Compact embankments in accordance with Section 132.4.1., "Ordinary Compaction," or Section 132.3.4.2., "Density Control," as shown on the plans.

3.4.1. Ordinary Compaction. Use approved rolling equipment complying with Item 210, "Rolling," to compact each layer. Use specific equipment when required by the plans or the Engineer. Do not allow the loose depth of any layer to exceed 8 in., unless otherwise approved. Bring each layer to the moisture content directed before and during rolling operations. Compact each layer until there is no evidence of further consolidation. Maintain a level layer to ensure uniform compaction. Recompact and refinish the subgrade at no additional expense to the Department if the required stability or finish is lost for any reason.

3.4.2. **Density Control**. Compact each layer to the required density using equipment complying with Item 210, "Rolling." Determine the maximum lift thickness based on the ability of the compacting operation and equipment to meet the required density. Do not exceed layer thickness of 16 in. loose or 12 in. compacted material unless otherwise approved. Maintain a level layer to ensure uniform compaction.

The Engineer will use Tex-114-E to determine the maximum dry density ($D_a$) and optimum moisture content ($W_{opt}$). Meet the requirements for field density and moisture content in Table 2 unless otherwise shown on the plans.

Table 2
Field Density Control Requirements

| Description | Density | Moisture Content |
|---|---|---|
| | Tex-115-E | |
| PI ≤ 15 | ≥ 98% $D_a$ | |
| 15 < PI ≤ 35 | ≥ 98% $D_a$ and ≤ 102% $D_a$ | ≥ $W_{opt.}$ |
| PI > 35 | ≥ 95% $D_a$ and ≤ 100% $D_a$ | ≥ $W_{opt.}$ |

Each layer is subject to testing by the Engineer for density and moisture content. During compaction, the moisture content of the soil should not exceed the value shown on the moisture-density curve, above optimum, required to achieve:

- 98% dry density for soils with a PI greater than 15 but less than or equal to 35 or
- 95% dry density for soils with PI greater than 35.

Remove small areas of the layer to allow for density tests as required. Replace the removed material and recompact at no additional expense to the Department. Proof-roll in accordance with Item 216, "Proof Rolling," when shown on the plans or as directed. Correct soft spots as directed.

3.5. **Maintenance of Moisture and Reworking**. Maintain the density and moisture content once all requirements in Table 2 are met. Maintain the moisture content no lower than 4% below optimum for soils with a PI greater than 15. Rework the material to obtain the specified compaction when the material loses the required stability, density, moisture, or finish. Alter the compaction methods and procedures on subsequent work to obtain specified density as directed.

3.6. **Acceptance Criteria**.

3.6.1. **Grade Tolerances**.

3.6.1.1. **Staged Construction**. Grade to within 0.1 ft. in the cross-section and 0.1 ft. in 16 ft. measured longitudinally.

3.6.1.2. **Turnkey Construction**. Grade to within 1/2 in. in the cross-section and 1/2 in. in 16 ft. measured longitudinally.

3.6.2. **Gradation Tolerances**. Ensure no more than 1 of the 5 most recent gradation tests is outside the specified limits on any individual sieve by more than 5% when gradation requirements are shown on the plans.

3.6.3. **Density Tolerances**. Ensure no more than 1 of the 5 most recent density tests for compaction work is outside the specified density limits, and no test is outside the limits by more than 3 pcf.

3.6.4. **Plasticity Tolerances**. Ensure no more than 1 of the 5 most recent PI tests for material is outside the specified limit by more than 2 points.

## 4. MEASUREMENT

Embankment will be measured by the cubic yard. Measurement will be further defined for payment as follows:

4.1. Final. The cubic yard will be measured in its final position using the average end area method. The volume is computed between the original ground surface or the surface upon which the embankment is to be constructed and the lines, grades, and slopes of the embankment. In areas of salvaged topsoil, payment for embankment will be made in accordance with Item 160, "Topsoil." Shrinkage or swell factors will not be considered in determining the calculated quantities.

4.2. Original. The cubic yard will be measured in its original and natural position using the average end area method.

4.3. Vehicle. The cubic yard will be measured in vehicles at the point of delivery.

When measured by the cubic yard in its final position, 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.

Shrinkage or swell factors are the Contractor's responsibility. When shown on the plans, factors are for informational purposes only.

Measurement of retaining wall backfill in embankment areas is paid for as embankment unless otherwise shown on the plans. Limits of measurement for embankment in retaining wall areas are 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 price bid for "Embankment (Final)," "Embankment (Original)," or "Embankment (Vehicle)" of the compaction method and type specified. This price is full compensation for furnishing embankment; hauling; placing, compacting, finishing, and reworking; disposal of waste material; and equipment, labor, tools, and incidentals.

When proof rolling is directed, it will be paid for in accordance with Item 216, "Proof Rolling."

All sprinkling and rolling, except proof rolling, will not be paid for directly but will be considered subsidiary to this Item, unless otherwise shown on the plans.

Where subgrade is constructed under this Contract, correction of soft spots in the subgrade will be at the Contractor's expense. Where subgrade is not constructed under this Contract, correction of soft spots in the subgrade will be paid in accordance with Article 9.7., "Payment for Extra Work and Force Account Method."

# Item 134
# Backfilling Pavement Edges

## 1. DESCRIPTION

Backfill pavement edges in conformance with the typical sections shown on the plans.

## 2. MATERIALS

2.1. **Backfill Material**. Use backfill material capable of sustaining vegetation unless otherwise specified on the plans. Furnish backfill material of one of the following types:

2.1.1. **Type A**. Backfill secured from a source outside the right of way and according to the requirements as shown on the plans.

2.1.2. **Type B**. Backfill secured from within the existing right of way as shown on the plans or as directed.

2.2. **Emulsified Asphalt**. Furnish the type specified on the plans and meeting the requirements of Item 300, "Asphalts, Oils, and Emulsions."

## 3. CONSTRUCTION

Haul the backfill material to the required location before placing the finish surface course unless directed otherwise. Spread, compact, and shape the backfill material in accordance with the typical sections after placing the finish surface course. Do not drag, push, or scrape material across completed pavement.

3.1. **Types A and B Backfill**. Bring the backfill material to the approved moisture content. Shape to the lines and grades shown on the plans, and compact as directed. Blade the roadway side-slopes to a smooth surface after compacting the backfill.

3.2. **Type C Backfill**. Place mulch sod in a uniform windrow, and keep moist as directed. Cultivate the area to receive mulch sod to a depth of 4 in. Blade and shape the mulch sod across the area in varying depths as shown on the typical sections to produce a smooth and uniform slope. Roll with a light roller or other suitable equipment. Moisten to the maximum depth of the backfill, after applying fertilizer, as directed.

3.4. **Emulsified Asphalt**. Apply the emulsified asphalt mixture in accordance with Article 314.4., "Construction," after final finishing of the backfill material, at the specified amount and rate of application as shown on the plans.

## 4. MEASUREMENT

This Item will be measured by the 100-ft. station along the baseline of each roadbed.

## 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 “Backfill” of the type specified. This price is full compensation for furnishing the emulsified asphalt, water, fertilizer, and backfill material; and for equipment, labor, materials, tools, and incidentals.

# Item 150
# Blading

## 1. DESCRIPTION

Blade portions of the project limits as shown on the plans or as directed.

## 2. EQUIPMENT

Provide equipment able to effectively produce the desired results. Use a dual or four-wheel drive power maintainer equipped with pneumatic tires, a blade at least 12 ft. in length, and a wheelbase of no less than
16 ft. when work is measured and paid by the number of hours of blading. Provide a scarifier if the maintainer is not equipped with a scarifier attachment.

## 3. CONSTRUCTION

Blade all areas to the section, line, and grade shown on the plans. Use a scarifier when necessary to loosen materials before blading. Use hand methods or other means around structures, trees, and other obstructions if doing the work with a blade is impractical. Do not drag, push, or scrape material along or across completed pavement.

## 4. MEASUREMENT

This Item will be measured by the 100-ft. station along the base line of each roadbed or by the number of hours of blading, including scarifying, performed.

## 5. 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 “Blading.” This price is full compensation for furnishing and operating equipment and for labor, materials, tools, and incidentals.

Work done by hand labor methods adjacent to structures, trees, and other obstructions is not paid for directly but will be considered subsidiary to this Item. Work performed under this Item will not include work specified for payment under other Items.

# Item 152
# Road Grader Work

## 1. DESCRIPTION

Construct subgrade and adjacent slopes. Construct portions of the roadway according to the typical sections as shown on the plans where finished grade is uncontrolled. Move earthwork of minor volumes and for short distances only. Move earthwork within the limits as shown on the plans and in at least 500-ft. sections, except on bridge projects.

## 2. EQUIPMENT

Provide equipment in accordance with Article 150.2., "Equipment."

## 3. CONSTRUCTION

Remove or rework unsuitable or unstable materials in accordance with Article 110.2., "Construction," or as directed. Grade the roadway and shape to the typical sections shown on the plans. Finish to a profile uniform and consistent with the topography.

## 4. MEASUREMENT

This Item will be measured by the 100-ft. station as measured along the baseline of each roadbed or by the square yard.

## 5. 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 "Road Grader Work (Ordinary Compaction)" or "Road Grader Work (Density Control)." This price is full compensation for furnishing and operating equipment and for labor, materials, tools, and incidentals.

"Sprinkling" and "Rolling" will not be paid for directly but will be subsidiary to this Item. All work involved in removing and replacing or reworking unsuitable or unstable material will be paid for as specified under Item 110, "Excavation," when the Contract includes bid items governed by Item 110, "Excavation," otherwise it will be paid for under Article 9.7., "Payment for Extra Work and Force Account Method." The work performed under this Item will not include work specified for payment under other Items.

# Item 160
# Topsoil

## 1. DESCRIPTION

Furnish and place topsoil to the depths and on the areas shown on the plans.

## 2. MATERIALS

Use easily cultivated, fertile topsoil that is free from objectionable material and resists erosion. Obtain topsoil from the right of way at sites of proposed excavation or embankment when specified on the plans, or as directed. Secure additional topsoil, if necessary, from approved sources outside the right of way in accordance with the requirements of Article 7.7., "Preservation of Cultural and Natural Resources and the Environment." Ensure that the topsoil obtained from sites outside the right of way has a pH of 5.5 to 8.5, per Tex-128-E. Topsoil is subject to testing by the Engineer.

## 3. CONSTRUCTION

Remove and dispose of objectionable material from the topsoil source before beginning the work. Stockpile topsoil, when necessary, in a windrow at designated locations along the right of way line or as directed. Keep source and stockpile areas drained during the period of topsoil removal and leave them in a neat condition when removal is complete. Cultivate the area to a depth of 4 in. before placing topsoil. Spread the topsoil to a uniform loose cover at the thickness specified. Place and shape the topsoil as directed. Water and roll the topsoil with a light roller or other suitable equipment.

## 4. MEASUREMENT

This Item will be measured by the 100-ft. station along the baseline of each roadbed, by the square yard complete in place, or by the cubic yard in vehicles at the point of delivery.

## 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 "Furnishing and Placing Topsoil" of the depth specified on the plans (except for measurement by the cubic yard). This price is full compensation for securing necessary sources and royalties; furnishing topsoil; excavation, loading, hauling, stockpiling and placing; watering; rolling; and equipment, labor, materials, tools, and incidentals. Limits of excavation and embankment for payment are shown in Figure 1.

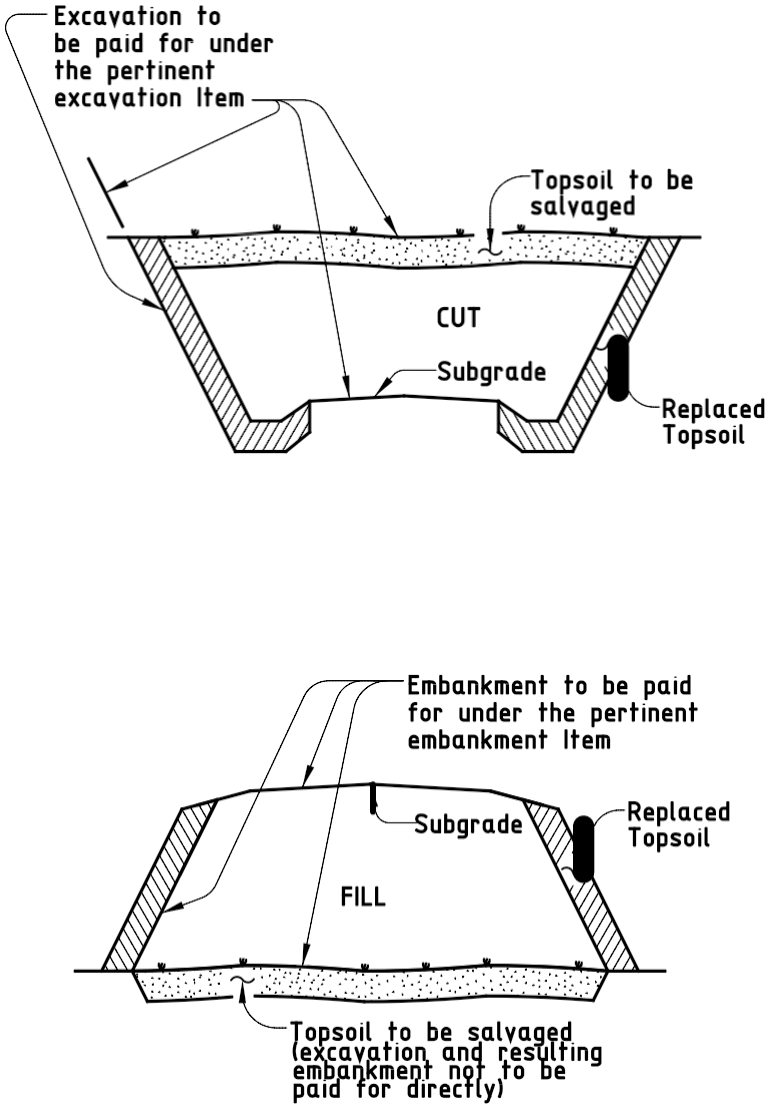


Figure 1
Roadway Cross-Sections Showing Payment for Excavation and Embankment

# Item 204
# Sprinkling

## 1. DESCRIPTION

Apply water for dust control, earthwork, or base construction.

## 2. MATERIALS

Furnish water free of industrial wastes and other objectionable matter.

## 3. EQUIPMENT

Use sprinklers and spray bars equipped with positive and rapidly working cut-off valves.

## 4. CONSTRUCTION

Apply water at a uniform rate and in the required quantity, or as directed.

## 5. MEASUREMENT

This Item will be measured by the 1,000 gal. applied.

## 6. PAYMENT

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

When sprinkling is specified on the plans as a pay item, the work performed and water furnished will be paid for at the unit price bid for “Sprinkling (Base),” “Sprinkling (Earthwork),” or “Sprinkling (Dust Control).” This price is full compensation for furnishing and applying water; furnishing and operating sprinklers and measuring devices; and hauling, equipment, labor, fuel, materials, tools, and incident

# Item 210
# Rolling

## 1. DESCRIPTION

Compact embankment, subgrade, base, surface treatments, broken concrete pavement, or asphalt pavement using rollers. Break up asphalt mats, pit run material, or base materials.

## 2. EQUIPMENT

Use any type of roller to meet the production rates and quality requirements of the Contract unless otherwise shown on the plans or directed. Use equipment that meets the requirements of Table 1 when specific types of equipment are required. The Engineer may allow the use of rollers that operate in one direction only when turning does not affect the quality of work or encroach on traffic.

Table 1
Roller Requirements[1]

| Roller Type | Materials to be Compacted | Load (tons) | Contact Pressure | Roller Speed (mph) |
|---|---|---|---|---|
| Steel wheel | Embankment, subgrade, base, asphalt concrete | ≥ 10 | ≥ 325 lb. per inch of wheel width | 2–3 |
| Tamping | Embankment, subgrade | – | 125–550 psi per tamping foot | 2–3 |
| Heavy tamping | Embankment, subgrade | – | ≥ 550 psi per tamping foot | 2–3 |
| Vibratory | Embankment, subgrade, base, asphalt concrete | Type A < 6<br>Type B > 6<br>Type C as shown on the plans | Per equipment specification and as approved | As approved |
| Light pneumatic | Embankment, subgrade, surface treatment | 4.5–9.0 | ≥ 45 psi | 2–6 |
| | Asphalt Concrete | | | 4–12 |
| Medium pneumatic | Embankment, subgrade, base, surface treatment | 12–25 | ≥ 80 psi, as directed | 2–6 |
| | Asphalt Concrete | | | 4–12 |
| Heavy pneumatic | Embankment, subgrade, base, previously broken concrete pavement, other pavements | ≥ 25 | ≤ 150 psi | 2–6 |
| Grid | Embankment, breaking up existing asphalt mats or base | 5–13 | – | 2–3 |

1. Unless otherwise specified in the Contract.

2.1. **Static Steel Wheel Rollers**. Furnish single, double, or triple steel wheel, self-propelled power rollers weighing at least 10 tons capable of operating in a forward and backward motion. Ensure all wheels are flat. The Contractor may use vibratory rollers in the static mode when static steel wheel rollers are required.

For single steel wheel rollers, pneumatic rear wheels are allowed for embankment, subgrade, and base. Provide rear wheels for triple steel wheel rollers with a minimum diameter of 48 in., a minimum width of 20 in., and a minimum compression of 325 lb. per inch of wheel width.

2.2. **Tamping Rollers**. Furnish self-propelled rollers with at least one self-cleaning metal tamping drum capable of operating in a forward or backward motion with a minimum effective rolling width of 5 ft. Mount drums in a frame so that each drum moves independently of the other for rollers with more than one drum. Operate rollers in static or vibratory mode.

2.2.1. **Tamping Roller (Minimum Requirement)**. Provide tamping feet that exert a static load of 125 to 550 psi and project at least 3 in. from the surface of the drum for all tamping rollers except for heavy tamping rollers.

2.2.2. **Heavy Tamping Roller**. Provide tamping rollers that have:

- 2 metal tamping drums, rolls, or shells, each with a 60-in. minimum diameter and a 5-ft. minimum width, or
- 1 rear and 2 forward drums, each with a 60-in. minimum diameter. Arrange drums so that the rear drum compacts the space between the 2 forward drums and the minimum overall rolling width is 10 ft.

Equip drums with tamping feet that:

- project at least 7 in. from the drum surface,
- have an area of 7 to 21 sq. in.,
- are self-cleaning,
- exert a static load of at least 550 psi, and
- are spaced at 1 tamping foot per 0.65 to 0.70 square feet of drum area.

2.3. **Vibratory Rollers**. Furnish self-propelled rollers with at least one drum equipped to vibrate. Select and maintain amplitude and frequency settings per manufacturer's specifications to deliver maximum compaction without material displacement or shoving, as approved. Furnish the equipment manufacturer's specifications concerning settings and controls for amplitude and frequency. Operate rollers at speeds that will produce at least 10 blows per foot unless otherwise shown on the plans or approved. Pneumatic rear wheels are allowed for embankment, subgrade, and base. Equip each vibrating drum with:

- separate frequency and amplitude controls,
- controls to manually start and stop vibration, and
- a mechanism to continuously clean the face of the drum.

For asphalt-stabilized base and asphalt concrete pavement, furnish a roller that also has the ability to:

- automatically reverse the direction of the rotating eccentric weight,
- stop vibration before the motion of the roller stops, and
- thoroughly moisten the drum with water or approved asphalt release agent.

2.3.1. **Drum (Type A)**. Furnish a roller with a static weight less than 6 tons and a vibratory drum.

2.3.2. **Drum (Type B)**. Furnish a roller with a minimum static weight of 6 tons and a vibratory drum.

2.3.3. **Drum (Type C)**. Furnish a roller as shown on the plans.

2.4. **Pneumatic Tire Rollers**. Pneumatic tire rollers consist of rubber tire wheels on axles mounted in a frame with either a loading platform or body suitable for ballast loading. Arrange the rear tires to cover the gaps between adjacent tires of the forward group. Furnish rollers capable of forward and backward motion.

Compact asphalt pavements and surface treatments with a roller equipped with smooth-tread tires. Compact without damaging the surface. Moisten the wheels with water or an approved asphalt release agent when necessary.

Select and maintain the operating load and tire air pressure within the range of the manufacturer's charts or tabulations to attain maximum compaction throughout the lift, as approved. Furnish the manufacturer's chart or tabulations showing the contact areas and contact pressures for the full range of tire inflation pressures and for the full range of loadings for the particular tires furnished. Maintain individual tire inflation pressures within 5 psi of each other. Provide uniform compression under all tires.

2.4.1. Light Pneumatic Tire. Furnish a unit:

- with at least 9 pneumatic tires,
- with an effective rolling width of approximately 5 ft.,
- capable of providing a total uniform load of 4.5 to 9 tons, and
- with tires capable of maintaining a minimum ground contact pressure of 45 psi.

2.4.2. Medium Pneumatic Tire. Furnish a unit:

- with at least 7 pneumatic tires,
- with an effective rolling width of approximately 7 ft.,
- capable of providing a total uniform load of 12 to 25 tons, and
- with tires capable of maintaining a minimum ground contact pressure of 80 psi or 90 psi as directed.

2.4.3. Heavy Pneumatic Tire. Furnish a unit:

- with at least 4 pneumatic-tired wheels mounted on axles carrying no more than 2 wheels,
- with wheels arranged to carry approximately equal loads on uneven surfaces,
- with a width between 8 and 10 ft. that can turn 180° in the crown width,
- capable of providing a total uniform load of at least 25 tons,
- with tires capable of maintaining a maximum ground contact pressure of 150 psi, and
- with liquid-filled tires inflated to such a level that liquid will flow from the valve stem when the stem is in the uppermost position.

2.5. Grid Rollers. Furnish rollers that have 2 cylindrical cages with a minimum diameter of 66 in. and a minimum width of 32 in. Mount cages in a rigid frame with weight boxes. Use a cage surface of cast or welded steel fabric grid with bars 1-1/2 in. wide, spaced on 5-in. centers in each direction, that undulate approximately 1 in. between the high and low points.

Furnish rollers capable of providing a total load of 5 to 13 tons and capable of being operated in a forward or backward motion.

2.6. Alternate Equipment. The Contractor may use alternate compaction equipment that produces results equivalent to the specified equipment as approved. Discontinue the use of the alternate equipment and furnish the specified equipment if the desired results are not achieved.

## 3. CONSTRUCTION

Perform this work in accordance with the applicable Items using equipment and roller speeds specified in Table 1. Use only rubber-tired equipment to push or pull compaction equipment on base courses. Use equipment that does not damage material being rolled.

## 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 216
# Proof Rolling

## 1. DESCRIPTION

Proof-roll earthwork, base, or both to locate unstable areas.

## 2. EQUIPMENT

2.1. Specified Equipment. Furnish rollers that weigh at least 25 tons when loaded. The maximum acceptable load is 50 tons. Provide rollers that meet the requirements of Section 210.2.4., "Pneumatic Tire Rollers."

2.2. Alternative Equipment. The Contractor may use alternate compaction equipment that produces results equivalent to the specified equipment in the same period of time as approved. Discontinue the use of the alternative equipment and furnish the specified equipment if the desired results are not achieved.

## 3. CONSTRUCTION

Perform proof rolling as directed. Adjust the load and tire inflation pressures within the range of the manufacturer's charts or tabulations, as directed. Make at least 2 coverage's with the proof roller. Offset each trip of the roller by at most one tire width. Operate rollers at a speed between 2 and 6 mph, as directed. Correct unstable or non-uniform areas, if found, in accordance with the applicable Item.

## 4. MEASUREMENT

Rolling will be measured by the hour operated on surfaces being tested.

## 5. PAYMENT

The work performed and equipment furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Proof Rolling." This price is full compensation for furnishing and operating equipment and for labor, materials, tools, and incidentals.

# Item 247
# Flexible Base

## 1. DESCRIPTION

Construct a foundation course composed of flexible base.

## 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 may sample and test project materials at any time before compaction throughout the duration of the project to assure specification compliance. Use Tex-100-E material definitions.

2.1. Aggregate. Furnish aggregate of the type and grade shown on the plans and meeting the requirements of Table 1. Each source must meet Table 1 requirements for liquid limit, plasticity index, and wet ball mill for the grade specified. Do not use additives, such as but not limited to lime, cement, or fly ash to modify aggregates to meet the requirements of Table 1 unless shown on the plans.

Table 1
Material Requirements

| Property | Test Method | Grade 1–2 | Grade 3 | Grade 4[2] | Grade 5 |
|---|---|---|---|---|---|
| Sampling | Tex-400-A | | | | |
| Master gradation sieve size (cumulative % retained) | Tex-110-E | | | | |
| 2-1/2" | | 0 | 0 | As shown on the plans | 0 |
| 1-3/4" | | 0–10 | 0–10 | | 0–5 |
| 7/8" | | 10–35 | – | | 10–35 |
| 3/8" | | 30–65 | – | | 35–65 |
| #4 | | 45–75 | 45–75 | | 45–75 |
| #40 | | 65–90 | 50–85 | | 70–90 |
| Liquid Limit, % Max | Tex-104-E | 40 | 40 | As shown on the plans | 35 |
| Plasticity Index, Max[1] | Tex-106-E | 10 | 12 | As shown on the plans | 10 |
| Plasticity index, Min[1] | | As shown on the plans | As shown on the plans | As shown on the plans | As shown on the plans |
| Wet ball mill, % Max | Tex-116-E | 40 | – | As shown on the plans | 40 |
| Wet ball mill, % Max increase passing the #40 sieve | | 20 | – | As shown on the plans | 20 |
| Min compressive strength, psi | Tex-117-E | | | As shown on the plans | |
| lateral pressure 0 psi | | 35 | – | | – |
| lateral pressure 3 psi | | – | – | | 90 |
| lateral pressure 15 psi | | 175 | – | | 175 |

1. Determine plastic index in accordance with Tex-107-E (linear shrinkage) when liquid limit is unattainable as defined in Tex-104-E.
2. Grade 4 may be further designated as Grade 4A, Grade 4B, etc.

2.1.1. Material Tolerances. The Engineer may accept material if no more than 1 of the 5 most recent gradation tests has an individual sieve outside the specified limits of the gradation.

When target grading is required by the plans, no single failing test may exceed the master grading by more than 5 percentage points on sieves No. 4 and larger or 3 percentage points on sieves smaller than No. 4.

The Engineer may accept material if no more than 1 of the 5 most recent plasticity index tests is outside the specified limit. No single failing test may exceed the allowable limit by more than 2 points.

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2.1.2 **Material Types**. Do not use fillers or binders unless approved. Furnish the type specified on the plans in accordance with the following:

2.1.2.1. **Type A**. Crushed stone produced and graded from oversize quarried aggregate that originates from a single, naturally occurring source. Do not use gravel or multiple sources.

2.1.2.2. **Type B**. Crushed or uncrushed gravel. Blending of 2 or more sources is allowed.

2.1.2.3. **Type C**. Crushed gravel with a minimum of 60% of the particles retained on a No. 4 sieve with 2 or more crushed faces as determined by Tex-460-A, Part I. Blending of 2 or more sources is allowed.

2.1.2.4. **Type D**. Type A material or crushed concrete. Crushed concrete containing gravel will be considered Type D material. Crushed concrete must meet the requirements in Section 247.2.1.3.2., "Recycled Material (Including Crushed Concrete) Requirements," and be managed in a way to provide for uniform quality. The Engineer may require separate dedicated stockpiles in order to verify compliance.

2.1.2.5. **Type E**. Caliche, iron ore or as otherwise shown on the plans.

2.1.3. **Recycled Material**. Recycled asphalt pavement (RAP) and other recycled materials may be used when shown on the plans. Request approval to blend 2 or more sources of recycled materials.

2.1.3.1. **Limits on Percentage**. Do not exceed 20% RAP by weight, when RAP is allowed, unless otherwise shown on the plans. The percentage limitations for other recycled materials will be as shown on the plans.

2.1.3.2. **Recycled Material (Including Crushed Concrete) Requirements**.

2.1.3.2.1. **Contractor-Furnished Recycled Materials**. Provide recycled materials that have a maximum sulfate content of 3,000 ppm when tested in accordance with Tex-145-E. When the Contractor furnishes the recycled materials, including crushed concrete, the final product will be subject to the requirements of Table 1 for the grade specified. Certify compliance with DMS-11000, "Evaluating and Using Nonhazardous Recyclable Materials Guidelines," for Contractor furnished recycled materials. In addition, recycled materials must be free from reinforcing steel and other objectionable material and have at most 1.5% deleterious material when tested in accordance with Tex-413-A. For RAP, do not exceed a maximum percent loss from decantation of 5.0% when tested in accordance with Tex-406-A. Test RAP without removing the asphalt.

2.1.3.2.2. **Department-Furnished Required Recycled Materials**. When the Department furnishes and requires the use of recycled materials, unless otherwise shown on the plans:

- Department-required recycled material will not be subject to the requirements in Table 1,
- Contractor-furnished materials are subject to the requirements in Table 1 and this Item,
- the final product, blended, will be subject to the requirements in Table 1, and
- for final product, unblended (100% Department-furnished required recycled material), the liquid limit, plasticity index, wet ball mill, and compressive strength is waived.

Crush Department-furnished RAP so that 100% passes the 2 in. sieve. The Contractor is responsible for uniformly blending to meet the percentage required.

2.1.3.2.3. **Department-Furnished and Allowed Recycled Materials**. When the Department furnishes and allows the use of recycled materials or allows the Contractor to furnish recycled materials, the final blended product is subject to the requirements of Table 1 and the plans.

2.1.3.3. **Recycled Material Sources**. Department-owned recycled material is available to the Contractor only when shown on the plans. Return unused Department-owned recycled materials to the Department stockpile location designated by the Engineer unless otherwise shown on the plans.

The use of Contractor-owned recycled materials is allowed when shown on the plans. Contractor-owned surplus recycled materials remain the property of the Contractor. Remove Contractor-owned recycled materials from the project and dispose of them in accordance with federal, state, and local regulations before project acceptance. Do not intermingle Contractor-owned recycled material with Department-owned recycled material unless approved.

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

2.3. Material Sources. Expose the vertical faces of all strata of material proposed for use when non-commercial sources are used. Secure and process the material by successive vertical cuts extending through all exposed strata, when directed.

## 3. EQUIPMENT

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

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

3.2. When ride quality measurement is required, provide a high speed or lightweight inertial profiler certified at the Texas A&M Transportation Institute. Provide equipment certification documentation. Display a current decal on the equipment indicating the certification expiration date.

## 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.

Stockpile base material temporarily at an approved location before delivery to the roadway. Build stockpiles in layers no greater than 2 ft. thick. Stockpiles must have a total height between 10 and 16 ft. unless otherwise approved. After construction and acceptance of the stockpile, loading from the stockpile for delivery is allowed. Load by making successive vertical cuts through the entire depth of the stockpile.

Do not add or remove material from temporary stockpiles that require sampling and testing before delivery unless otherwise approved. Charges for additional sampling and testing required as a result of adding or removing material will be deducted from the Contractor's estimates.

Haul approved flexible base in clean trucks. Deliver the required quantity to each 100-ft. station or designated stockpile site as shown on the plans. Prepare stockpile sites as directed. When delivery is to the 100-ft. station, manipulate in accordance with the applicable Items.

4.1. Preparation of Subgrade or Existing Base. Remove or scarify existing asphalt concrete pavement in accordance with Item 105, "Removing Treated and Untreated Base and Asphalt Pavement," when shown on the plans or as directed. Shape the subgrade or existing base to conform to the typical sections shown on the plans or as directed.

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

Proof roll the roadbed in accordance with Item 216, "Proof Rolling," before pulverizing or scarifying when shown on the plans or directed. Correct soft spots as directed.

4.2. Placing. Spread and shape flexible base into a uniform layer with an approved spreader the same day as delivered unless otherwise approved. Construct layers to the thickness shown on the plans. Maintain the

shape of the course. Control dust by sprinkling, as directed. Correct or replace segregated areas as directed, at no additional expense to the Department.

Place successive base courses and finish courses using the same construction methods required for the first course.

4.3. Compaction. Compact using density control unless otherwise shown on the plans. Multiple lifts are permitted when shown on the plans or approved. 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 towards the center, overlapping on successive trips by at least 1/2 the width of the roller unit. Begin rolling at the low side and progress toward the high side on superelevated curves. Offset alternate trips of the roller. Operate rollers at a speed between 2 and 6 mph as directed.

Rework, re-compact, and refinish material that fails to meet or that loses required moisture, density, stability, or finish requirements 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.

Before final acceptance, the Engineer will select the locations of tests and measure the flexible base depth in accordance with Tex-140-E. Correct areas deficient by more than 1/2 in. in thickness by scarifying, adding material as required, reshaping, re-compacting, and refinishing at the Contractor's expense.

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 re-compacting.

4.3.2. Density Control. Compact to at least 100% of the maximum dry density determined by Tex-113-E, unless otherwise shown on the plans. Maintain moisture during compaction within ±2 percentage points of the optimum moisture content as determined by Tex-113-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. Do not achieve density by drying the material after compaction.

The Engineer will determine roadway density and moisture content 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. 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 loosened material and dispose of it at an approved location. Seal the clipped surface immediately by rolling 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 as shown on the plans or as directed.

Correct grade deviations greater than 1/4 in. in 16 feet measured longitudinally or greater than 1/4 in. over the entire width of the cross-section in areas where surfacing is to be placed. Correct by loosening and adding, or removing material. Reshape and re-compact in accordance with Section 247.4.3., "Compaction."

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

4.6. Ride Quality. This section applies to the final travel lanes that receive a 1 or 2 course surface treatment for the final surface, unless otherwise shown on the plans. Measure ride quality of the base course after placement of the prime coat and before placement of the surface treatment, unless otherwise approved. Use a certified profiler operator from the Department's MPL. When requested, furnish the Engineer documentation for the person certified to operate the profiler.

Provide all profile measurements to the Engineer in electronic data files within 3 days after placement of the prime coat using the format specified in Tex-1001-S. The Engineer will use Department software to evaluate longitudinal profiles to determine areas requiring corrective action. Correct 0.1-mi.sections having an average international roughness index (IRI) value greater than 100.0 in. per mile to an IRI value of 100.0 in. per mile or less for each wheel path, unless otherwise shown on the plans.

Re-profile and correct sections that fail to maintain ride quality until placement of the next course, as directed. Correct re-profiled sections until specification requirements are met, as approved. Perform this work at no additional expense to the Department.

## 5. MEASUREMENT

Flexible base will be measured as follows:

- Flexible Base (Complete In Place). The ton, square yard, or any cubic yard method.
- Flexible Base (Roadway Delivery). The ton or any cubic yard method.
- Flexible Base (Stockpile Delivery). The ton, cubic yard in vehicle, or cubic yard in stockpile.

Measurement by the cubic yard in final position and square yard is a plans quantity measurement. The quantity to be paid for 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.

Measurement is further defined for payment as follows.

5.1. Cubic Yard in Vehicle. By the cubic yard in vehicles of uniform capacity at the point of delivery.

5.2. Cubic Yard in Stockpile. By the cubic yard in the final stockpile position by the method of average end areas.

5.3. Cubic Yard in Final Position. By the cubic yard in the completed and accepted final position. The volume of base course is computed in place by the method of average end areas between the original subgrade or existing base surfaces and the lines, grades, and slopes of the accepted base course as shown on the plans.

5.4. Square Yard. By the square yard of surface area in the completed and accepted final position. The surface area of the base course is based on the width of flexible base as shown on the plans.

5.5. Ton. By the ton of dry weight in vehicles as delivered. 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 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 the types of work shown below. No additional payment will be made for thickness or width exceeding that shown on the typical section or provided on the plans for cubic yard in the final position or square yard measurement.

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, 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 will be at the Contractor's expense. Where subgrade is not constructed under this Contract, correction of soft spots in the subgrade will be paid in accordance with pertinent Items or Article 4.4., "Changes in the Work."

6.1. Flexible Base (Complete In Place). Payment will be made for the type and grade specified. For cubic yard measurement, "In Vehicle," "In Stockpile," or "In Final Position" will be specified. For square yard measurement, a depth will be specified. This price is full compensation for furnishing materials, temporary stockpiling, assistance provided in stockpile sampling and operations to level stockpiles for measurement, loading, hauling, delivery of materials, spreading, blading, mixing, shaping, placing, compacting, reworking, finishing, correcting locations where thickness is deficient, curing, furnishing scales and labor for weighing and measuring, and equipment, labor, tools, and incidentals.

6.2. Flexible Base (Roadway Delivery). Payment will be made for the type and grade specified. For cubic yard measurement, "In Vehicle," "In Stockpile," or "In Final Position" will be specified. The unit price bid will not include processing at the roadway. This price is full compensation for furnishing materials, temporary stockpiling, assistance provided in stockpile sampling and operations to level stockpiles for measurement, loading, hauling, delivery of materials, furnishing scales and labor for weighing and measuring, and equipment, labor, tools, and incidentals.

6.3. Flexible Base (Stockpile Delivery). Payment will be made for the type and grade specified. For cubic yard measurement, "In Vehicle" or "In Stockpile" will be specified. The unit price bid will not include processing at the roadway. This price is full compensation for furnishing and disposing of materials, preparing the stockpile area, temporary or permanent stockpiling, assistance provided in stockpile sampling and operations to level stockpiles for measurement, loading, hauling, delivery of materials to the stockpile, furnishing scales and labor for weighing and measuring, 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 super elevated 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, re-compact, 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 re-compacting.

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 re-compact 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.

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

# Item 260
# Lime Treatment (Road-Mixed)

## 1. DESCRIPTION

Mix and compact lime, water, and subgrade or base (with or without asphaltic 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. Obtain verification from the Engineer that the specification requirements are met before using the sources. The Engineer may sample and test project materials at any time before compaction. Use Tex-100-E for material definitions.

2.1. Lime. Furnish lime that meets the requirements of DMS-6350 "Lime and Lime Slurry," and DMS-6330, "Pre-Qualification of Lime Sources." Use hydrated lime, commercial lime slurry, quicklime, or carbide lime slurry as shown on the plans. Do not use quicklime when sulfates are present in quantities greater than 3,000 ppm. When furnishing quicklime, provide it in bulk.

2.2. Subgrade. The Engineer will determine the sulfate content of the existing subgrade in accordance with Tex-145-E and organic content in accordance with Tex-148-E before lime 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 lime.

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

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

2.6. Mix Design. The Engineer will determine the target lime content and optimum moisture content in accordance with Tex-121-E or prior experience with the project materials. The Contractor may propose a mix design developed in accordance with Tex-121-E. The Engineer will use Tex-121-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. Storage Facility. Store quicklime and dry hydrated lime in closed, weatherproof containers.

3.2. Slurry Equipment. Use slurry tanks equipped with agitation devices to slurry hydrated lime or quicklime on the project or other approved location. The Engineer may approve other slurrying methods.

3.3. Provide a pump for agitating the slurry when the distributer truck is not equipped with an agitator. Equip the distributor truck with a sampling device in accordance with Tex-600-J, Part I, when using commercial lime slurry or carbide lime slurry.

3.4. Hydrated Lime Distribution Equipment. Provide equipment to spread lime evenly across the area to be treated. Provide equipment with a rotary vane feeder to spread lime, when shown on the plans.

3.5. 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

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 pavement in accordance with Item 105, "Removing Treated and Untreated Base and Asphalt Pavement," when shown on the plans or as directed. Shape existing material in accordance with applicable bid items to conform to typical sections shown on the plans and as directed.

Unless otherwise approved, proof roll the roadbed in accordance with Item 216, "Proof Rolling," before pulverizing or scarifying existing material. Correct soft spots as directed.

When material is imported from a borrow source, notify the Engineer of the location of the borrow source well in advance 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 material 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 Lime. Uniformly apply lime using dry or slurry placement as shown on the plans or as directed. Add lime at the percentage determined in Section 260.2.6., "Mix Design." Apply lime only on an area where mixing can be completed during the same working day.

Start lime 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.

Minimize dust and scattering of lime by wind. Do not apply lime when wind conditions, in the opinion of the Engineer, cause blowing lime to become dangerous to traffic or objectionable to adjacent property owners. When pebble grade quicklime is placed dry, mix the material and lime thoroughly at the time of lime application. Use of quicklime can be dangerous. Inform users of the recommended precautions for handling and storage.

4.3.1. Dry Placement. Before applying lime, bring the prepared roadway to approximately 2 percentage points above optimum moisture content. When necessary, sprinkle in accordance with Item 204, "Sprinkling." Distribute the required quantity of hydrated lime or pebble grade quicklime with approved equipment. Only hydrated lime may be distributed by bag. Do not use a motor grader to spread hydrated lime.

4.3.2. Slurry Placement. Provide slurry free of objectionable materials, at or above the minimum dry solids content, and with a uniform consistency that will allow ease of handling and uniform application. Deliver commercial lime slurry or carbide lime slurry to the jobsite, or use hydrated lime or quicklime to prepare lime slurry at the jobsite or other approved location, as specified. When dry quicklime is applied as slurry, use 80% of the amount shown on the plans.

Distribute slurry uniformly by making successive passes over a measured section of roadway until the specified lime content is reached. Uniformly spread the residue from quicklime slurry over the length of the roadway being processed, unless otherwise directed.

4.4. Mixing. Begin mixing within 6 hr. of application of lime. Hydrated lime exposed to the open air for 6 hr. or more between application and mixing, or that experiences excessive loss due to washing or blowing, will not be accepted for payment.

Thoroughly mix the material and lime using approved equipment. When treating subgrade, bring the moisture content above the optimum moisture content to insure adequate chemical reaction of the lime and subgrade materials. Allow the mixture to mellow for 1 to 4 days, as directed. When pebble grade quicklime is used, allow the mixture to mellow for 2 to 4 days, as directed. Sprinkle the treated materials during the mixing and mellowing operation, as directed, to achieve adequate hydration and proper moisture content. When the material to be treated has a sulfate content greater than 3,000 ppm but less than or equal to 7,000 ppm, mellow for a minimum of 7 days. Maintain in a continuously moist condition by sprinkling in accordance with Item 204, "Sprinkling." After mellowing, resume mixing until a homogeneous, friable mixture is obtained. 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.

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 using density control, unless otherwise shown on the plans. Multiple lifts are permitted when shown on the plans or approved. Bring each layer to the moisture content directed. 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 no more than 1.0 percentage points below optimum and 2.0 percentage points above optimum as determined by Tex-121-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, unless otherwise shown on the plans or directed.

Begin rolling longitudinally at the sides and proceed toward the center, overlapping on successive trips by at least 1/2 the width of the roller unit. On super elevated 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 lime content by adding lime as required, reshaping, re-compacting, and refinishing at the Contractor's expense.

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. Rework in accordance with Section 260.4.6., "Reworking a Section." Perform the work at no additional expense 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 re-compacting.

4.5.2. Density Control. The Engineer will determine roadway density and moisture content 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.

4.5.2.1. Subgrade. Compact to at least 95% of the maximum density determined in accordance with Tex-121-E, unless otherwise shown on the plans.

4.5.2.2. Base. Compact the bottom course to at least 95% of the maximum density determined in accordance with Tex-121-E, unless otherwise shown on the plans. Compact subsequent courses treated under this Item to at least 98% of the maximum density determined in accordance with Tex-121-E, unless otherwise shown on the plans.

4.6. Reworking a Section. When a section is reworked within 72 hr. after completion of compaction, rework the section to provide the required density. When a section is reworked more than 72 hr. after completion of compaction, add additional lime at 25% of the percentage determined in Section 260.2.6., "Mix Design." Reworking includes loosening, adding material or removing unacceptable material if necessary, mixing as directed, compacting, and finishing. When density control is specified, determine a new maximum density of the reworked material in accordance with Tex-121-E, and compact to at least 95% of this density.

4.7. Finishing. Immediately after completing compaction of the final course, clip, skin, or tight-blade the surface of the lime-treated material with a maintainer or subgrade trimmer to a depth of approximately 1/4 in. Remove loosened material and dispose of at an approved location. Roll the clipped surface immediately 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.

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. The 72-hr. time limit required for completion of placement, compaction, and finishing does not apply to finishing required just before applying the surface course.

4.8. Curing. Cure for the minimum number of days shown in Table 2 by sprinkling in accordance with Item 204, "Sprinkling," or by applying an asphalt material at a rate of 0.05 to 0.20 gal. per square yard as directed. Maintain moisture during curing. Upon completion of curing, maintain the moisture content in accordance with Section 132.3.5., "Maintenance of Moisture and Reworking," for subgrade and Section 247.4.5., "Curing" for bases before placing subsequent courses. Do not allow equipment on the finished course during curing except as required for sprinkling, unless otherwise approved. Apply seals or additional courses within 14 calendar days of final compaction.

Table 2
Minimum Curing Requirements before Placing Subsequent Courses[1]

| Untreated Material | Curing (Days) |
|---|---|
| PI ≤ 35 | 2 |
| PI > 35 | 5 |

1. Subject to the approval of the Engineer. Proof rolling may be required as an indicator of adequate curing.

## 5. MEASUREMENT

5.1. **Lime**. When lime is furnished in trucks, the weight of lime 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 lime 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.

5.1.1. **Hydrated Lime**.

5.1.1.1. **Dry**. Lime will be measured by the ton (dry weight).

5.1.1.2. **Slurry**. Lime slurry will be measured by the ton (dry weight) of the hydrated lime used to prepare the slurry at the jobsite.

5.1.2. **Commercial Lime Slurry**. Lime slurry will be measured by the ton (dry weight) as calculated from the minimum percent dry solids content of the slurry, multiplied by the weight of the slurry in tons delivered.

5.1.3. **Quicklime**.

5.1.3.1. **Dry**. Lime will be measured by the ton (dry weight) of the quicklime.

5.1.3.2. **Slurry**. Lime slurry will be measured by the ton (dry weight) of the quicklime used to prepare the slurry multiplied by a conversion factor of 1.28 to give the quantity of equivalent hydrated lime, which will be the basis of payment.

5.1.4. **Carbide Lime Slurry**. Lime slurry will be measured by the ton (dry weight) as calculated from the minimum percent dry solids content of the slurry, multiplied by the weight of the slurry in tons delivered.

5.2. **Lime Treatment**. Lime treatment will be measured by the square yard of surface area. The dimensions for determining the surface area are established by the widths shown on the plans and the 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 260.6.1., "Lime," and Section 260.6.2., "Lime 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 in accordance with Section 260.6.2., "Lime 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 paid for 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 curing and priming will be paid for under Item 310, "Prime Coat."

6.1. Lime. Lime will be paid for at the unit price bid for "Lime" of one of the following types:

- Hydrated Lime (Dry),
- Hydrated Lime (Slurry),
- Commercial Lime Slurry,
- Quicklime (Dry),
- Quicklime (Slurry), or
- Carbide Lime Slurry.

This price is full compensation for materials, delivery, equipment, labor, tools, and incidentals.

Lime used for reworking a section in accordance with Section 260.4.6., "Reworking a Section," will not be paid for directly but will be subsidiary to this Item.

6.2. Lime Treatment. Lime treatment will be paid for at the unit price bid for "Lime Treatment (Existing Material)," "Lime Treatment (New Base)," or "Lime 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 lime, compacting, 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 300
# Asphalts, Oils, and Emulsions

## 1. DESCRIPTION

Provide asphalt cements, cutback and emulsified asphalts, performance-graded asphalt binders, and other miscellaneous asphalt materials as specified on the plans.

## 2. MATERIALS

Provide asphalt materials that meet the stated requirements when tested in accordance with the referenced Department, AASHTO, and ASTM test methods. Provide asphalt materials that have been preapproved for use by the Construction Division in accordance with Tex-545-C, "Asphalt Binder Quality Program," unless otherwise shown on the plans.

Acronyms used in this Item are defined in Table 1.

Table 1
Acronyms

| Acronym | Definition |
|---|---|
| Test Procedure Designations | |
| Tex | Department |
| T or R | AASHTO |
| D | ASTM |
| Polymer Modifier Designations | |
| P | polymer-modified |
| SBR or L | styrene-butadiene rubber (latex) |
| SBS | styrene-butadiene-styrene block co-polymer |
| TR | tire rubber (from ambient temperature grinding of truck and passenger tires) |
| AC | asphalt cement |
| AE | asphalt emulsion |
| AE-P | asphalt emulsion prime |
| A-R | asphalt-rubber |
| C | cationic |
| EAP&T | emulsified asphalt prime and tack |
| H-suffix | harder residue (lower penetration) |
| HF | high float |
| MC | medium-curing |
| MS | medium-setting |
| PCE | prime, cure, and erosion control |
| PG | performance grade |
| RC | rapid-curing |
| RS | rapid-setting |
| S-suffix | stockpile usage |
| SCM | special cutback material |
| SS | slow-setting |

2.1. **Asphalt Cement**. Provide asphalt cement that is homogeneous, water-free, and nonfoaming when heated to 347°F, and meets the requirements in Table 2.

Table 2
Asphalt Cement

| Property | Test Procedure | Viscosity Grade | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | AC-0.6 | | AC-1.5 | | AC-3 | | AC-5 | | AC-10 | |
| | | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max |
| Viscosity | T 202 | | | | | | | | | | |
| 140°F, poise | | 40 | 80 | 100 | 200 | 250 | 350 | 400 | 600 | 800 | 1,200 |
| 275°F, poise | | 0.4 | – | 0.7 | – | 1.1 | – | 1.4 | – | 1.9 | – |
| Penetration, 77°F, 100g, 5 sec. | T 49 | 350 | – | 250 | – | 210 | – | 135 | – | 85 | – |
| Flash point, C.O.C., °F | T 48 | 425 | – | 425 | – | 425 | – | 425 | – | 450 | – |
| Solubility in trichloroethylene, % | T 44 | 99.0 | – | 99.0 | – | 99.0 | – | 99.0 | – | 99.0 | – |
| Spot test | Tex-509-C | Neg. | | Neg. | | Neg. | | Neg. | | Neg. | |
| Tests on residue from Thin-Film Oven Test: | T 179 | | | | | | | | | | |
| Viscosity, 140°F, poise | T 202 | – | 180 | – | 450 | – | 900 | – | 1,500 | – | 3,000 |
| Ductility,[1] 77°F 5 cm/min., cm | T 51 | 100 | – | 100 | – | 100 | – | 100 | – | 100 | – |

1. If AC-0.6 or AC-1.5 ductility at 77°F is less than 100 cm, material is acceptable if ductility at 60°F is more than 100 cm.

2.2. **Polymer-Modified Asphalt Cement**. Provide polymer-modified asphalt cement that is smooth, homogeneous, and meets the requirements of Table 3. Supply samples of the base asphalt cement and polymer additives if requested.

Table 3
Polymer-Modified Asphalt Cement

| Property | Test Procedure | Polymer-Modified Viscosity Grade | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | AC-5 w/2% SBR | | AC-10 w/2% SBR | | AC-15P | | AC-20XP | | AC-10-2TR | | AC-20-5TR | |
| | | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max |
| Polymer | | SBR | | SBR | | SBS | | SBS | | TR | | TR | |
| Polymer content, % (solids basis) | Tex-533-C | 2.0 | – | 2.0 | – | 3.0 | – | – | – | 2.0 | – | 5.0 | – |
| Dynamic shear, G*/sin δ, 64°C, 10 rad/s, kPa | T 315 | – | – | – | – | – | – | 1.0 | – | – | – | 1.0 | – |
| Dynamic shear, G*/sin δ, 58°C, 10 rad/s, kPa | T 315 | – | – | – | – | – | – | – | – | 1.0 | – | – | – |
| Viscosity | | | | | | | | | | | | | |
| 140°F, poise | T 202 | 700 | – | 1,300 | – | 1,500 | – | 2,000 | – | 1,000 | – | 2,000 | – |
| 275°F, poise | T 202 | – | 7.0 | – | 8.0 | – | 8.0 | – | – | – | 8.0 | – | 10.0 |
| Penetration, 77°F, 100 g, 5 sec. | T 49 | 120 | – | 80 | – | 100 | 150 | 75 | 115 | 95 | 130 | 75 | 115 |
| Ductility, 5cm/min., 39.2°F, cm | T 51 | 70 | – | 60 | – | – | – | – | – | – | – | – | – |
| Elastic recovery, 50°F, % | Tex-539-C | – | – | – | – | 55 | – | 55 | – | 30 | – | 55 | – |
| Softening point, °F | T 53 | – | – | – | – | – | – | 120 | – | 110 | – | 120 | – |
| Polymer separation, 48 hr. | Tex-540-C | None | | None | | None | | None | | None | | None | |
| Flash point, C.O.C., °F | T 48 | 425 | – | 425 | – | 425 | – | 425 | – | 425 | – | 425 | – |
| Tests on residue from RTFOT aging and pressure aging: | Tex-541-C and R 28 | | | | | | | | | | | | |
| Creep stiffness | T 313 | | | | | | | | | | | | |
| S, -18°C, MPa | | – | – | – | – | – | 300 | – | 300 | – | 300 | – | 300 |
| m-value, -18°C | | – | – | – | – | 0.300 | – | 0.300 | – | 0.300 | – | 0.300 | – |

2.3. **Cutback Asphalt**. Provide cutback asphalt that meets the requirements of Tables 4, 5, and 6 for the specified type and grade. Supply samples of the base asphalt cement and polymer additives if requested.

Table 4
Rapid-Curing Cutback Asphalt

| Property | Test Procedure | Type–Grade | | | | | |
|---|---|---|---|---|---|---|---|
| | | RC-250 | | RC-800 | | RC-3000 | |
| | | Min | Max | Min | Max | Min | Max |
| Kinematic viscosity, 140°F, cSt | T 201 | 250 | 400 | 800 | 1,600 | 3,000 | 6,000 |
| Water, % | D95 | – | 0.2 | – | 0.2 | – | 0.2 |
| Flash point, T.O.C., °F | T 79 | 80 | – | 80 | – | 80 | – |
| Distillation test: | T 78 | | | | | | |
| Distillate, percentage by volume of total distillate to 680°F | | | | | | | |
| to 437°F | | 40 | 75 | 35 | 70 | 20 | 55 |
| to 500°F | | 65 | 90 | 55 | 85 | 45 | 75 |
| to 600°F | | 85 | – | 80 | – | 70 | – |
| Residue from distillation, volume % | | 70 | – | 75 | – | 82 | – |
| Tests on distillation residue: | | | | | | | |
| Viscosity, 140°F, poise | T 202 | 60 | 240 | 60 | 240 | 60 | 240 |
| Ductility, 5 cm/min., 77°F, cm | T 51 | 100 | – | 100 | – | 100 | – |
| Solubility in trichloroethylene, % | T 44 | 99.0 | – | 99.0 | – | 99.0 | – |
| Spot test | Tex-509-C | Neg. | | Neg. | | Neg. | |

Table 5
Medium-Curing Cutback Asphalt

| Property | Test Procedure | Type–Grade | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | MC-30 | | MC-250 | | MC-800 | | MC-3000 | |
| | | Min | Max | Min | Max | Min | Max | Min | Max |
| Kinematic viscosity, 140°F, cSt | T 201 | 30 | 60 | 250 | 500 | 800 | 1,600 | 3,000 | 6,000 |
| Water, % | D95 | – | 0.2 | – | 0.2 | – | 0.2 | – | 0.2 |
| Flash point, T.O.C., °F | T 79 | 95 | – | 122 | – | 140 | – | 149 | – |
| Distillation test: | T 78 | | | | | | | | |
| Distillate, percentage by volume of total distillate to 680°F | | | | | | | | | |
| to 437°F | | – | 35 | – | 20 | – | – | – | – |
| to 500°F | | 30 | 75 | 5 | 55 | – | 40 | – | 15 |
| to 600°F | | 75 | 95 | 60 | 90 | 45 | 85 | 15 | 75 |
| Residue from distillation, volume % | | 50 | – | 67 | – | 75 | – | 80 | – |
| Tests on distillation residue: | | | | | | | | | |
| Viscosity, 140°F, poise | T 202 | 30 | 120 | 30 | 120 | 30 | 120 | 30 | 120 |
| Ductility, 5 cm/min., 77°F, cm | T 51 | 100 | – | 100 | – | 100 | – | 100 | – |
| Solubility in trichloroethylene, % | T 44 | 99.0 | – | 99.0 | – | 99.0 | – | 99.0 | – |
| Spot test | Tex-509-C | Neg. | | Neg. | | Neg. | | Neg. | |

Table 6
Special-Use Cutback Asphalt

| Property | Test Procedure | Type–Grade | | | | | |
|---|---|---|---|---|---|---|---|
| | | MC-2400L | | SCM I | | SCM II | |
| | | Min | Max | Min | Max | Min | Max |
| Kinematic viscosity, 140°F, cSt | T 201 | 2,400 | 4,800 | 500 | 1,000 | 1,000 | 2,000 |
| Water, % | D95 | – | 0.2 | – | 0.2 | – | 0.2 |
| Flash point, T.O.C., °F | T 79 | 150 | – | 175 | – | 175 | – |
| Distillation test: | T 78 | | | | | | |
| Distillate, percentage by volume of total distillate to 680°F | | | | | | | |
| to 437°F | | – | – | – | – | – | – |
| to 500°F | | – | 35 | – | 0.5 | – | 0.5 |
| to 600°F | | 35 | 80 | 20 | 60 | 15 | 50 |
| Residue from distillation, volume % | | 78 | – | 76 | – | 82 | – |
| Tests on distillation residue: | | | | | | | |
| Polymer | | SBR | | – | | – | |
| Polymer content, % (solids basis) | Tex-533-C | 2.0 | – | – | – | – | – |
| Penetration, 100 g, 5 sec., 77°F | T 49 | 150 | 300 | 180 | – | 180 | – |
| Ductility, 5 cm/min., 39.2°F, cm | T 51 | 50 | – | – | – | – | – |
| Solubility in trichloroethylene, % | T 44 | 99.0 | – | 99.0 | – | 99.0 | – |

2.4. **Emulsified Asphalt**. Provide emulsified asphalt that is homogeneous, does not separate after thorough mixing, and meets the requirements for the specified type and grade in Tables 7, 8, 9, and 10.

Table 7
Emulsified Asphalt

| Property | Test Procedure | Type–Grade | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Rapid-Setting | | Medium-Setting | | | | Slow-Setting | | | |
| | | HFRS-2 | | MS-2 | | AES-300 | | SS-1 | | SS-1H | |
| | | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max |
| Viscosity, Saybolt Furol | T 72 | | | | | | | | | | |
| 77°F, sec. | | – | – | – | – | 75 | 400 | 20 | 100 | 20 | 100 |
| 122°F, sec. | | 150 | 400 | 100 | 300 | – | – | – | – | – | – |
| Sieve test, % | T 59 | – | 0.1 | – | 0.1 | – | 0.1 | – | 0.1 | – | 0.1 |
| Miscibility | T 59 | – | | – | | – | | Pass | | Pass | |
| Cement mixing, % | T 59 | – | – | – | – | – | – | – | 2.0 | – | 2.0 |
| Coating ability and water resistance: | T 59 | | | | | | | | | | |
| Dry aggregate/after spray | | – | | – | | Good/Fair | | – | | – | |
| Wet aggregate/after spray | | – | | – | | Fair/Fair | | – | | – | |
| Demulsibility, 35 ml of 0.02 N $CaCl_2$, % | T 59 | 50 | – | – | 30 | – | – | – | – | – | – |
| Storage stability, 1 day, % | T 59 | – | 1 | – | 1 | – | 1 | – | 1 | – | 1 |
| Freezing test, 3 cycles[1] | T 59 | – | | Pass | | – | | Pass | | Pass | |
| Distillation test: | T 59 | | | | | | | | | | |
| Residue by distillation, % by wt. | | 65 | – | 65 | – | 65 | – | 60 | – | 60 | – |
| Oil distillate, % by volume of emulsion | | – | 0.5 | – | 0.5 | – | 5 | – | 0.5 | – | 0.5 |
| Tests on residue from distillation: | | | | | | | | | | | |
| Penetration, 77°F, 100 g, 5 sec. | T 49 | 100 | 140 | 120 | 160 | 300 | – | 120 | 160 | 70 | 100 |
| Solubility in trichloroethylene, % | T 44 | 97.5 | – | 97.5 | | 97.5 | – | 97.5 | – | 97.5 | – |
| Ductility, 77°F, 5 cm/min., cm | T 51 | 100 | – | 100 | | – | – | 100 | – | 80 | – |
| Float test, 140°F, sec. | T 50 | 1,200 | – | – | | 1,200 | – | – | – | – | – |

1. Applies only when the Engineer designates material for winter use.

Table 8
Cationic Emulsified Asphalt

| Property | Test Procedure | Type–Grade | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Rapid-Setting | | | | Medium-Setting | | | | Slow-Setting | | | |
| | | CRS-2 | | CRS-2H | | CMS-2 | | CMS-2S | | CSS-1 | | CSS-1H | |
| | | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max |
| Viscosity, Saybolt Furol | | | | | | | | | | | | | |
| 77°F, sec. | T 72 | – | – | – | – | – | – | – | – | 20 | 100 | 20 | 100 |
| 122°F, sec. | | 150 | 400 | 150 | 400 | 100 | 300 | 100 | 300 | – | – | – | – |
| Sieve test, % | T 59 | – | 0.1 | – | 0.1 | – | 0.1 | – | 0.1 | – | 0.1 | – | 0.1 |
| Cement mixing, % | T 59 | – | – | – | – | – | – | – | – | – | 2.0 | – | 2.0 |
| Coating ability and water resistance: | | | | | | | | | | | | | |
| Dry aggregate/after spray | T 59 | – | | – | | Good/Fair | | Good/Fair | | – | | – | |
| Wet aggregate/after spray | | – | | – | | Fair/Fair | | Fair/Fair | | – | | – | |
| Demulsibility, 35 ml of 0.8% Sodium dioctyl sulfosuccinate, % | T 59 | 70 | – | 70 | – | – | – | – | – | – | – | – | – |
| Storage stability, 1 day, % | T 59 | – | 1 | – | 1 | – | 1 | – | 1 | – | 1 | – | 1 |
| Particle charge | T 59 | Positive | | Positive | | Positive | | Positive | | Positive | | Positive | |
| Distillation test: | | | | | | | | | | | | | |
| Residue by distillation, % by wt. | T 59 | 65 | – | 65 | – | 65 | – | 65 | – | 60 | – | 60 | – |
| Oil distillate, % by volume of emulsion | | – | 0.5 | – | 0.5 | – | 7 | – | 5 | – | 0.5 | – | 0.5 |
| Tests on residue from distillation: | | | | | | | | | | | | | |
| Penetration, 77°F, 100 g, 5 sec. | T 49 | 120 | 160 | 70 | 110 | 120 | 200 | 300 | – | 120 | 160 | 70 | 110 |
| Solubility in trichloroethylene, % | T 44 | 97.5 | – | 97.5 | – | 97.5 | – | 97.5 | – | 97.5 | – | 97.5 | – |
| Ductility, 77°F, 5 cm/min., cm | T 51 | 100 | – | 80 | – | 100 | – | – | – | 100 | – | 80 | – |

Table 9
Polymer-Modified Emulsified Asphalt

| Property | Test Procedure | Type–Grade | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Rapid-Setting | | | | Medium-Setting | | | | Slow-Setting | | | |
| | | RS-1P | | HFRS-2P | | AES-150P | | AES-300P | | AES-300S | | SS-1P | |
| | | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max |
| Viscosity, Saybolt Furol | T 72 | | | | | | | | | | | | |
| 77°F, sec. | | – | – | – | – | 75 | 400 | 75 | 400 | 75 | 400 | 30 | 100 |
| 122°F, sec. | | 50 | 200 | 150 | 400 | – | – | – | – | – | – | – | – |
| Sieve test, % | T 59 | – | 0.1 | – | 0.1 | – | 0.1 | – | 0.1 | – | 0.1 | – | 0.1 |
| Miscibility | T 59 | – | | – | | – | | – | | – | | Pass | |
| Coating ability and water resistance: | T 59 | | | | | | | | | | | | |
| Dry aggregate/after spray | | – | | – | | Good/Fair | | Good/Fair | | Good/Fair | | – | |
| Wet aggregate/after spray | | – | | – | | Fair/Fair | | Fair/Fair | | Fair/Fair | | – | |
| Demulsibility, 35 ml of 0.02 N $CaCl_2$, % | T 59 | 60 | – | 50 | – | – | – | – | – | – | – | – | – |
| Storage stability, 1 day, % | T 59 | – | 1 | – | 1 | – | 1 | – | 1 | – | 1 | – | 1 |
| Breaking index, g | Tex-542-C | – | 80 | – | – | – | – | – | – | – | – | – | – |
| Distillation test:[1] | T 59 | | | | | | | | | | | | |
| Residue by distillation, % by wt. | | 65 | – | 65 | – | 65 | – | 65 | – | 65 | – | 60 | – |
| Oil distillate, % by volume of emulsion | | – | 3 | – | 0.5 | – | 3 | – | 5 | – | 7 | – | 0.5 |
| Tests on residue from distillation: | | | | | | | | | | | | | |
| Polymer content, wt. % (solids basis) | Tex-533-C | – | – | 3.0 | – | – | – | – | – | – | – | 3.0 | – |
| Penetration, 77°F, 100 g, 5 sec. | T 49 | 225 | 300 | 90 | 140 | 150 | 300 | 300 | – | 300 | – | 100 | 140 |
| Solubility in trichloroethylene, % | T 44 | 97.0 | – | 97.0 | – | 97.0 | – | 97.0 | – | 97.0 | – | 97.0 | – |
| Viscosity, 140°F, poise | T 202 | – | – | 1,500 | – | – | – | – | – | – | – | 1,300 | – |
| Float test, 140°F, sec. | T 50 | – | – | 1,200 | – | 1,200 | – | 1,200 | – | 1,200 | – | – | – |
| Ductility,[2] 39.2°F, 5 cm/min., cm | T 51 | – | – | 50 | – | – | – | – | – | – | – | 50 | – |
| Elastic recovery,[2] 50°F, % | Tex-539-C | 55 | – | 55 | – | – | – | – | – | – | – | – | – |
| Tests on RTFO curing of distillation residue | Tex-541-C | | | | | | | | | | | | |
| Elastic recovery, 50°F, % | Tex-539-C | – | – | – | – | 50 | – | 50 | – | 30 | – | – | – |

1. Exception to T 59: Bring the temperature on the lower thermometer slowly to 350°F ±10°F. Maintain at this temperature for 20 min. Complete total distillation in 60 min. (±5 min.) from the first application of heat.
2. HFRS-2P must meet one of either the ductility or elastic recovery requirements.

Table 10
Polymer-Modified Cationic Emulsified Asphalt

| Property | Test Procedure | Type-Grade | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Rapid-Setting | | | | | | Medium-Setting | | | | Slow-Setting | |
| | | CRS-1P | | CRS-2P | | CHFRS-2P | | CMS-1P[3] | | CMS-2P[3] | | CSS-1P | |
| | | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max | Min | Max |
| Viscosity, Saybolt Furol | T 72 | | | | | | | | | | | | |
| 77°F, sec. | | – | – | – | – | – | – | 20 | 100 | – | – | 20 | 100 |
| 122°F, sec. | | 50 | 150 | 150 | 400 | 100 | 400 | – | – | 50 | 400 | – | – |
| Sieve test, % | T 59 | – | 0.1 | – | 0.1 | – | 0.1 | – | 0.1 | – | 0.1 | – | 0.1 |
| Demulsibility, 35 ml of 0.8% Sodium dioctyl sulfosuccinate, % | T 59 | 60 | – | 70 | – | 60 | – | – | – | – | – | – | – |
| Storage stability, 1 day, % | T 59 | – | 1 | – | 1 | – | 1 | – | – | – | – | – | 1 |
| Breaking index, g | Tex-542-C | – | 80 | – | – | – | – | – | – | – | – | – | – |
| Particle charge | T 59 | Positive | | Positive | | Positive | | Positive | | Positive | | Positive | |
| Distillation test:[1] | T 59 | | | | | | | | | | | | |
| Residue by distillation, % by weight | | 65 | – | 65 | – | 65 | – | 65 | – | 65 | – | 62 | – |
| Oil distillate, % by volume of emulsion | | – | 3 | – | 0.5 | – | 0.5 | – | 0.5 | – | 0.5 | – | 0.5 |
| Tests on residue from distillation: | | | | | | | | | | | | | |
| Polymer content, wt. % (solids basis) | Tex-533-C | – | – | 3.0 | – | 3.0 | – | – | – | – | – | 3.0 | – |
| Penetration, 77°F, 100 g, 5 sec. | T 49 | 225 | 300 | 90 | 150 | 80 | 130 | 40 | – | 40 | – | 55 | 90 |
| Viscosity, 140°F, poise | T 202 | – | – | 1,300 | – | 1,300 | – | – | 5,000 | – | 5,000 | – | – |
| Solubility in trichloroethylene, % | T 44 | 97.0 | – | 97.0 | – | 95.0 | – | – | – | – | – | 97.0 | – |
| Softening point, °F | T 53 | – | – | – | – | 130 | – | – | – | – | – | 135 | – |
| Ductility, 77°F, 5 cm/min., cm | T 51 | – | – | – | – | – | – | – | – | – | – | 70 | – |
| Float test, 140°F, sec. | T 50 | – | – | – | – | 1,800 | – | – | – | – | – | | |
| Ductility,[2] 39.2°F, 5 cm/min., cm | T 51 | – | – | 50 | – | – | – | – | – | – | – | – | – |
| Elastic recovery,[2] 50°F, % | Tex-539-C | 45 | – | 55 | – | 55 | – | 45 | – | 45 | – | – | – |
| Tests on rejuvenating agent: | | | | | | | | | | | | | |
| Viscosity, 140°F, cSt | T 201 | – | – | – | – | – | – | 50 | 175 | 50 | 175 | – | – |
| Flash point, C.O.C., °F | T 48 | – | – | – | – | – | – | 380 | – | 380 | – | – | – |
| Saturates, % by weight | D2007 | – | – | – | – | – | – | – | 30 | – | 30 | – | – |
| Solubility in n-pentane, % by weight | D2007 | – | – | – | – | – | – | 99 | – | 99 | – | – | – |
| Tests on rejuvenating agent after TFO or RTFO: | T 240 or T 179 | | | | | | | | | | | | |
| Weight Change, % | | – | – | – | – | – | – | – | 6.5 | – | 6.5 | – | – |
| Viscosity Ratio | | – | – | – | – | – | – | – | 3.0 | – | 3.0 | – | – |
| Tests on latex:[4] | | | | | | | | | | | | | |
| Tensile strength, die C dumbbell, psi | D412[5] | – | – | – | – | – | – | 500 | – | 500 | – | – | – |
| Change in mass after immersion in rejuvenating agent, % | D471 | – | – | – | – | – | – | – | 40[6] | – | 40[6] | – | – |

1. Exception to T 59: Bring the temperature on the lower thermometer slowly to 350°F (±0°F). Maintain at this temperature for 20 min. Complete total distillation in 60 min. (±5 min.) from the first application of heat.
2. CRS-2P must meet one of either the ductility or elastic recovery requirements.
3. With all precertification samples of CMS-1P or CMS-2P, submit certified test reports showing that the rejuvenating agent and latex meet the stated requirements. Submit samples of these raw materials if requested by the Engineer.
4. Preparation of latex films: Use any substrate which produces a film of uniform cross-section. Apply latex using a drawdown tool that will deliver enough material to achieve desired residual thickness. Cure films for 14 days at 75°F and 50% relative humidity.
5. Cut samples for tensile strength determination using a crosshead speed of 20 in./min.
6. Specimen must remain intact after exposure and removal of excess rejuvenating agent.

2.5. **Specialty Emulsions**. Provide specialty emulsion that is either asphalt-based or resin-based and meets the requirements of Table 11.

Table 11
Specialty Emulsions

| Property | Test Procedure | Type–Grade | | | | | |
|---|---|---|---|---|---|---|---|
| | | Medium-Setting | | | | Slow-Setting | |
| | | AE–P | | EAP&T | | PCE[1] | |
| | | Min | Max | Min | Max | Min | Max |
| Viscosity, Saybolt Furol | T 72 | | | | | | |
| 77°F, sec. | | – | – | – | – | 10 | 100 |
| 122°F, sec. | | 15 | 150 | – | – | – | – |
| Sieve test, % | T 59 | – | 0.1 | – | 0.1 | – | 0.1 |
| Miscibility[2] | T 59 | – | | Pass | | Pass | |
| Demulsibility, 35 ml of 0.10 N $CaCl_2$, % | T 59 | – | 70 | – | – | – | – |
| Storage stability, 1 day, % | T 59 | – | 1 | – | 1 | – | – |
| Particle size,[5] % by volume < 2.5 μm | Tex-238-F[3] | – | – | 90 | – | 90 | – |
| Asphalt emulsion distillation to 500°F followed by Cutback asphalt distillation of residue to 680°F: | T 59 & T 78 | | | | | | |
| Residue after both distillations, % by wt. | | 40 | – | – | – | – | – |
| Total oil distillate from both distillations, % by volume of emulsion | | 25 | 40 | – | – | – | – |
| Residue by distillation, % by wt. | T 59 | – | – | 60 | – | – | – |
| Residue by evaporation,[4] % by wt. | T 59 | – | – | – | – | 60 | – |
| Tests on residue after all distillation(s): | | | | | | | |
| Viscosity, 140°F, poise | T 202 | – | – | 800 | – | – | – |
| Kinematic viscosity,[5] 140°F, cSt | T 201 | – | – | – | – | 100 | 350 |
| Flash point C.O.C., °F | T 48 | – | – | – | – | 400 | – |
| Solubility in trichloroethylene, % | T 44 | 97.5 | – | – | – | – | – |
| Float test, 122°F, sec. | T 50 | 50 | 200 | – | – | – | – |

Supply with each shipment of PCE:
a copy of a lab report from an approved analytical lab, signed by a lab official, indicating the PCE formulation does not meet any characteristics of a Resource Conservation Recovery Act (RCRA) hazardous waste;
a certification from the producer that the formulation supplied does not differ from the one tested and that no listed RCRA hazardous wastes or Polychlorinated Biphenyls (PCBs) have been mixed with the product; and
a Material Safety Data Sheet.
Exception to T 59: In dilution, use 350 ml of distilled or deionized water and a 1,000-ml beaker.
Use Tex-238-F, beginning at "Particle Size Analysis by Laser Diffraction," with distilled or deionized water as a medium and no dispersant, or use another approved method.
Exception to T 59: Leave sample in the oven until foaming ceases, then cool and weigh.
PCE must meet either the kinematic viscosity requirement or the particle size requirement.

2.6. **Recycling Agent**. Recycling agent and emulsified recycling agent must meet the requirements in Table 12. Additionally, recycling agent and residue from emulsified recycling agent, when added in the specified proportions to the recycled asphalt, must meet the properties specified on the plans.

Table 12
Recycling Agent and Emulsified Recycling Agent

| Property | Test Procedure | Recycling Agent | | Emulsified Recycling Agent | |
|---|---|---|---|---|---|
| | | Min | Max | Min | Max |
| Viscosity, Saybolt Furol, 77°F, sec. | T 72 | – | – | 15 | 100 |
| Sieve test, % | T 59 | – | – | – | 0.1 |
| Miscibility[1] | T 59 | – | | No coagulation | |
| Residue by evaporation,[2] % by wt. | T 59 | – | – | 60 | – |
| Tests on recycling agent or residue from evaporation: | | | | | |
| Flash point, C.O.C., °F | T 48 | 400 | – | 400 | – |
| Kinematic viscosity, | T 201 | | | | |
| 140°F, cSt | | 75 | 200 | 75 | 200 |
| 275°F, cSt | | – | 10.0 | – | 10.0 |

1. Exception to T 59: Use 0.02 N CaCl2 solution in place of water.
2. Exception to T 59: Maintain sample at 300°F until foaming ceases, then cool and weigh.

2.7. **Crumb Rubber Modifier**. Crumb rubber modifier (CRM) consists of automobile and truck tires processed by ambient temperature grinding.

CRM must be:

- free from contaminants including fabric, metal, and mineral and other non-rubber substances;
- free-flowing; and
- nonfoaming when added to hot asphalt binder.

Ensure rubber gradation meets the requirements of the grades in Table 13 when tested in accordance with Tex-200-F, Part I, using a 50-g sample.

Table 13
CRM Gradations

| Sieve Size (% Passing) | Grade A | | Grade B | | Grade C | | Grade D | Grade E |
|---|---|---|---|---|---|---|---|---|
| | Min | Max | Min | Max | Min | Max | | |
| #8 | 100 | – | – | – | – | – | As shown on the plans | As approved |
| #10 | 95 | 100 | 100 | – | – | – | | |
| #16 | – | – | 70 | 100 | 100 | – | | |
| #30 | – | – | 25 | 60 | 90 | 100 | | |
| #40 | – | – | – | – | 45 | 100 | | |
| #50 | 0 | 10 | – | – | – | – | | |
| #200 | – | – | 0 | 5 | – | – | | |

2.8. **Crack Sealer**. Provide polymer-modified asphalt-emulsion crack sealer meeting the requirements of Table 14. Provide rubber-asphalt crack sealer meeting the requirements of Table 15.

Table 14
Polymer-Modified Asphalt-Emulsion Crack Sealer

| Property | Test Procedure | Min | Max |
|---|---|---|---|
| Rotational viscosity, 77°F, cP | D2196, Method A | 10,000 | 25,000 |
| Sieve test, % | T 59 | – | 0.1 |
| Storage stability, 1 day, % | T 59 | – | 1 |
| Evaporation<br>Residue by evaporation, % by wt. | Tex-543-C | <br>65 | <br>– |
| Tests on residue from evaporation:<br>Penetration, 77°F, 100 g, 5 sec.<br>Softening point, °F<br>Ductility, 39.2°F, 5 cm/min., cm | <br>T 49<br>T 53<br>T 51 | <br>35<br>140<br>100 | <br>75<br>–<br>– |

Table 15
Rubber-Asphalt Crack Sealer

| Property | Test Procedure | Class A | | Class B | |
|---|---|---|---|---|---|
| | | Min | Max | Min | Max |
| CRM content, Grade A or B, % by wt. | Tex-544-C | 22 | 26 | – | – |
| CRM content, Grade B, % by wt. | Tex-544-C | – | – | 13 | 17 |
| Virgin rubber content,[1] % by wt. | | – | – | 2 | – |
| Flash point,[2] C.O.C., °F | T 48 | 400 | – | 400 | – |
| Penetration,[3] 77°F, 150 g, 5 sec. | T 49 | 30 | 50 | 30 | 50 |
| Penetration,[3] 32°F, 200 g, 60 sec. | T 49 | 12 | – | 12 | – |
| Softening point, °F | T 53 | – | – | 170 | – |
| Bond Test, non-immersed, 0.5 in specimen, 50% extension, 20°F[4] | D5329 | – | | Pass | |

1. Provide certification that the Min % virgin rubber was added.
2. Agitate the sealing compound with a 3/8- to 1/2-in. (9.5- to 12.7-mm) wide, square-end metal spatula to bring the material on the bottom of the cup to the surface (i.e., turn the material over) before passing the test flame over the cup. Start at one side of the thermometer, move around to the other, and then return to the starting point using 8 to 10 rapid circular strokes. Accomplish agitation in 3 to 4 sec. Pass the test flame over the cup immediately after stirring is completed.
3. Exception to T 49: Substitute the cone specified in D217 for the penetration needle.
4. Allow no crack in the crack sealing materials or break in the bond between the sealer and the mortar blocks over 1/4 in. deep for any specimen after completion of the test.

2.9. **Asphalt-Rubber Binders**. Provide asphalt-rubber (A-R) binders that are mixtures of asphalt binder and CRM, which have been reacted at elevated temperatures. Provide A-R binders meeting D6114 and containing a minimum of 15% CRM by weight. Provide Types I or II, containing CRM Grade C, for use in hot-

mixed aggregate mixtures. Provide Types II or III, containing CRM Grade B, for use in surface treatment binder. Ensure binder properties meet the requirements of Table 16.

Table 16
A-R Binders

| Property | Test Procedure | Binder Type | | | | | |
|---|---|---|---|---|---|---|---|
| | | Type I | | Type II | | Type III Min | |
| | | | Max | Min | Max | Min | Max |
| Apparent viscosity, 347°F, cP | D2196, Method A | 1,500 | 5,000 | 1,500 | 5,000 | 1,500 | 5,000 |
| Penetration, 77°F, 100 g, 5 sec. | T 49 | 25 | 75 | 25 | 75 | 50 | 100 |
| Penetration, 39.2°F, 200 g, 60 sec. | T 49 | 10 | – | 15 | – | 25 | – |
| Softening point, °F | T 53 | 135 | – | 130 | – | 125 | – |
| Resilience, 77°F, % | D5329 | 25 | – | 20 | – | 10 | – |
| Flash point, C.O.C., °F | T 48 | 450 | – | 450 | – | 450 | – |
| Tests on residue from Thin-Film Oven Test: | T 179 | | | | | | |
| Retained penetration ratio, 39.2°F, 200 g, 60 sec., % of original | T 49 | 75 | – | 75 | – | 75 | – |

2.10. Performance-Graded Binders. Provide PG binders that are smooth and homogeneous, show no separation when tested in accordance with Tex-540-C, and meet the requirements of Table 17.

Separation testing is not required if:

- a modifier is introduced separately at the mix plant either by injection in the asphalt line or mixer,
- the binder is blended on site in continuously agitated tanks, or
- binder acceptance is based on field samples taken from an in-line sampling port at the hot-mix plant after the addition of modifiers.

Table 17
Performance-Graded Binders

| Property and Test Method | Performance Grade | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PG 58 | | | PG 64 | | | | PG 70 | | | | PG 76 | | | | PG 82 | | |
| | -22 | -28 | -34 | -16 | -22 | -28 | -34 | -16 | -22 | -28 | -34 | -16 | -22 | -28 | -34 | -16 | -22 | -28 |
| Average 7-day max pavement design temperature, °C[1] | < 58 | | | < 64 | | | | < 70 | | | | < 76 | | | | < 82 | | |
| Min pavement design temperature, °C[1] | >-22 | >-28 | >-34 | >-16 | >-22 | >-28 | >-34 | >-16 | >-22 | >-28 | >-34 | >-16 | >-22 | >-28 | >-34 | >-16 | >-22 | >-28 |
| Original Binder | | | | | | | | | | | | | | | | | | |
| Flash point, T 48, Min, °C | 230 | | | | | | | | | | | | | | | | | |
| Viscosity, T 316:[2,3] Max, 3.0 Pa·s, test temperature, °C | 135 | | | | | | | | | | | | | | | | | |
| Dynamic shear, T 315:[4] G*/sin(δ), Min, 1.00 kPa, Max, 2.00 kPa,[7] Test temperature @ 10 rad/sec., °C | 58 | | | 64 | | | | 70 | | | | 76 | | | | 82 | | |
| Elastic recovery, D6084, 50°F, % Min | – | – | 30 | – | – | 30 | 50 | – | 30 | 50 | 60 | 30 | 50 | 60 | 70 | 50 | 60 | 70 |
| Rolling Thin-Film Oven (Tex-541-C) | | | | | | | | | | | | | | | | | | |
| Mass loss, Tex-541-C, Max, % | 1.0 | | | | | | | | | | | | | | | | | |
| Dynamic shear, T 315: G*/sin(δ), Min, 2.20 kPa, Max, 5.00 kPa,[7] Test temperature @ 10 rad/sec., °C | 58 | | | 64 | | | | 70 | | | | 76 | | | | 82 | | |
| Pressure Aging Vessel (PAV) Residue (R 28) | | | | | | | | | | | | | | | | | | |
| PAV aging temperature, °C | 100 | | | | | | | | | | | | | | | | | |
| Dynamic shear, T 315: G*sin(δ), Max, 5,000 kPa Test temperature @ 10 rad/sec., °C | 25 | 22 | 19 | 28 | 25 | 22 | 19 | 28 | 25 | 22 | 19 | 28 | 25 | 22 | 19 | 28 | 25 | 22 |
| Creep stiffness, T 313:[5,6] *S*, max, 300 MPa, *m*-value, Min, 0.300 Test temperature @ 60 sec., °C | -12 | -18 | -24 | -6 | -12 | -18 | -24 | -6 | -12 | -18 | -24 | -6 | -12 | -18 | -24 | -6 | -12 | -18 |
| Direct tension, T 314:[6] Failure strain, Min, 1.0% Test temperature @ 1.0 mm/min., °C | -12 | -18 | -24 | -6 | -12 | -18 | -24 | -6 | -12 | -18 | -24 | -6 | -12 | -18 | -24 | -6 | -12 | -18 |

1. Pavement temperatures are estimated from air temperatures using an algorithm contained in a Department-supplied computer program, may be provided by the Department, or by following the procedures outlined in AASHTO MP 2 and PP 28.
2. This requirement may be waived at the Department's discretion if the supplier warrants that the asphalt binder can be adequately pumped, mixed, and compacted at temperatures that meet all applicable safety, environmental, and constructability requirements. At test temperatures where the binder is a Newtonian fluid, any suitable standard means of viscosity measurement may be used, including capillary (T 201 or T 202) or rotational viscometry (T 316).
3. Viscosity at 135°C is an indicator of mixing and compaction temperatures that can be expected in the lab and field. High values may indicate high mixing and compaction temperatures. Additionally, significant variation can occur from batch to batch. Contractors should be aware that variation could significantly impact their mixing and compaction operations. Contractors are therefore responsible for addressing any constructability issues that may arise.
4. For quality control of unmodified asphalt binder production, measurement of the viscosity of the original asphalt binder may be substituted for dynamic shear measurements of G*/sin(δ) at test temperatures where the asphalt is a Newtonian fluid. Any suitable standard means of viscosity measurement may be used, including capillary (T 201 or T 202) or rotational viscometry (T 316).
5. Silicone beam molds, as described in AASHTO TP 1-93, are acceptable for use.
6. If creep stiffness is below 300 MPa, direct tension test is not required. If creep stiffness is between 300 and 600 MPa, the direct tension failure strain requirement can be used instead of the creep stiffness requirement. The m-value requirement must be satisfied in both cases.
7. Maximum values for unaged and RTFO aged dynamic shear apply only to materials used as substitute binders, as described in specification item 340.

## 3. EQUIPMENT

Provide all equipment necessary to transport, store, sample, heat, apply, and incorporate asphalts, oils, and emulsions.

## 4. CONSTRUCTION

Typical Material Use. Use materials shown in Table 18, unless otherwise determined by the Engineer.

Table 18
Typical Material Use

| Material Application | Typically Used Materials |
|---|---|
| Hot-mixed, hot-laid asphalt mixtures | PG binders, A-R binders Types I and II |
| Surface treatment | AC-5, AC-10, AC-5 w/2% SBR, AC-10 w/2% SBR, AC-15P, AC-20XP, AC-10-2TR, AC-20-5TR, HFRS-2, MS-2, CRS-2, CRS-2H, HFRS-2P,CRS-2P, CHFRS-2P, A-R binders Types II and III |
| Surface treatment (cool weather) | RS-1P, CRS-1P, RC-250, RC-800, RC-3000, MC-250, MC-800, MC-3000, MC-2400L |
| Precoating | AC-5, AC-10, PG 64-22, SS-1, SS-1H, CSS-1, CSS-1H |
| Tack coat | PG Binders, SS-1H, CSS-1H, EAP&T |
| Fog seal | SS-1, SS-1H, CSS-1, CSS-1H |
| Hot-mixed, cold-laid asphalt mixtures | AC-0.6, AC-1.5, AC-3, AES-300, AES-300P, CMS-2, CMS-2S |
| Patching mix | MC-800, SCM I, SCM II, AES-300S |
| Recycling | AC-0.6, AC-1.5, AC-3, AES-150P, AES-300P, recycling agent, emulsified recycling agent |
| Crack sealing | SS-1P, polymer mod AE crack sealant, rubber asphalt crack sealers (Class A, Class B) |
| Microsurfacing | CSS-1P |
| Prime | MC-30, AE-P, EAP&T, PCE |
| Curing membrane | SS-1, SS-1H, CSS-1, CSS-1H, PCE |
| Erosion control | SS-1, SS-1H, CSS-1, CSS-1H, PCE |

4.1. Storage and Application Temperatures. Use storage and application temperatures in accordance with Table 19. Store and apply materials at the lowest temperature yielding satisfactory results. Follow the manufacturer's instructions for any agitation requirements in storage. Manufacturer's instructions regarding recommended application and storage temperatures supersede those of Table 19.

Table 19
Storage and Application Temperatures

| Type–Grade | Application | | Storage Maximum (°F) |
|---|---|---|---|
| | Recommended Range (°F) | Maximum Allowable (°F) | |
| AC-0.6, AC-1.5, AC-3 | 200–300 | 350 | 350 |
| AC-5, AC-10 | 275–350 | 350 | 350 |
| AC-5 w/2% SBR, AC-10 w/2% SBR, AC-15P, AC-20-5TR | 300–375 | 375 | 360 |
| RC-250 | 125–180 | 200 | 200 |
| RC-800 | 170–230 | 260 | 260 |
| RC-3000 | 215–275 | 285 | 285 |
| MC-30, AE-P | 70–150 | 175 | 175 |
| MC-250 | 125–210 | 240 | 240 |
| MC-800, SCM I, SCM II | 175–260 | 275 | 275 |
| MC-3000, MC-2400L | 225–275 | 290 | 290 |
| HFRS-2, MS-2, CRS-2, CRS-2H, HFRS-2P, CRS-2P, CMS-2, CMS-2S, AES-300, AES-300S, AES-150P, AES-300P | 120–160 | 180 | 180 |
| SS-1, SS-1H, CSS-1, CSS-1H, PCE, EAP&T, SS-1P, RS-1P, CRS-1P, CSS-1P, recycling agent, emulsified recycling agent, polymer mod AE crack sealant | 50–130 | 140 | 140 |
| PG binders | 275–350 | 350 | 350 |
| Rubber asphalt crack sealers (Class A, Class B) | 350–375 | 400 | – |
| A-R binders Types I, II, and III | 325–425 | 425 | 425 |

## 5. MEASUREMENT AND PAYMENT

The work performed, materials furnished, equipment, labor, tools, and incidentals will not be measured or paid for directly but is subsidiary or is included in payment for other pertinent Items.

# Item 301
# Asphalt Antistripping Agents

## 1. DESCRIPTION

Furnish and incorporate all required asphalt antistripping agents in asphalt concrete paving mixtures and asphalt-stabilized base mixtures to meet moisture resistance testing requirements.

## 2. MATERIALS

2.1. **Lime**. Provide hydrated lime or commercial lime slurry in accordance with DMS-6350, "Lime and Lime Slurry."

2.2. **Liquid Antistripping Agent**. Provide a liquid antistripping agent that is uniform and shows no evidence of crystallization, settling, or separation.

Ensure all liquid antistripping agents arrive in:

- properly labeled and unopened containers, as shipped from the manufacturer, or
- sealed tank trucks with an invoice to show contents and quantities.

Provide product information to the Engineer including:

- material safety data sheet,
- specific gravity of the agent at the manufacturer's recommended addition temperature,
- manufacturer's recommended dosage range, and
- handling and storage instructions.

## 3. EQUIPMENT

Provide all equipment to store, handle, dispense, meter, and mix asphalt antistripping agents.

## 4. CONSTRUCTION

4.1. **Laboratory Design Evaluation and Production Mixture Verification**. Provide a laboratory mixture design and production mixture that meet moisture resistance requirements. Evaluate proposed asphalt pavement or base mixtures during design and production according to the moisture resistance requirements in the asphalt mixture specification.

Governing specifications require the Contractor or Engineer to design the mixture, and the party performing the design is responsible for the moisture susceptibility evaluation. If the Contractor designs the mixture, the Engineer verifies compliance.

Determine the dosage needed to achieve the moisture resistance requirements during design if an antistripping agent is required. Use this addition rate in the production mixture.

Add between 0.5% and 2.0% of hydrated lime or commercial lime slurry solids by weight of the individual aggregate treated when using lime.

Add liquid antistripping agent, when used, to the binder, in accordance with the manufacturer's instructions. Do not exceed the manufacturer's maximum recommended dosage rate.

Stop production if the production mixture does not meet moisture resistance requirements and correct the problem.

4.2. Addition of Antistripping Agents at the Mix Plant. Connect the measuring device for the addition of the asphalt antistripping agent into the automatic plant controls to automatically adjust the supply to plant production and provide a consistent percentage in the mixture. Set automatic plant controls so that an interruption of asphalt antistripping agent's flow causes plant shutdown.

4.2.1. Lime. Incorporate lime in a manner that thoroughly and uniformly distributes lime onto the aggregate surface or into the mixture. Use metering equipment, as approved, to ensure the required quantity of lime is used.

4.2.1.1. Hydrated Lime. Add hydrated lime to the aggregate by one of the following methods, unless otherwise shown on the plans:

- Mix in an approved pug mill mixer with damp aggregate containing water at least 2% above saturated surface dry conditions.
- Add into the drum-mix plant immediately before asphalt binder addition or in the pug mill of the weigh- batch plant before asphalt binder addition. Dry mix aggregates and lime before adding asphalt binder when a weigh batch plant is used.

4.2.1.2. Commercial Lime Slurry. Add commercial lime slurry to the aggregate by one of the following methods unless otherwise shown on the plans:

- Mix in a suitable pug mill mixer with the aggregate.
- Mix with aggregate between the plant cold feeds and the dryer or mixing drum during mixture production.

4.2.2. Liquid Antistripping Agent. Incorporate liquid antistripping agent into the binder as follows:

- Handle in accordance with the manufacturer's recommendations.
- Add at the manufacturer's recommended addition temperature.
- Place the metering and blending devices in an approved location.

## 5. MEASUREMENT AND PAYMENT

The work performed, materials furnished, equipment, labor, tools, and incidentals will not be measured or paid for directly but is subsidiary or is included in payment quantity for other pertinent Items.

# Item 302
# Aggregates for Surface Treatments

## 1. DESCRIPTION

Furnish aggregate for surface treatments in conformance to the type, grade, and Surface Aggregate Classification (SAC) shown on the plans.

## 2. MATERIALS

Furnish uncontaminated materials of uniform quality throughout that meet the requirements of the plans and specifications. Notify the Engineer of all proposed material sources and of changes to material sources. The Engineer will designate the sampling location.

2.1. Aggregate. Stockpile aggregates for each source and type separately. Do not add materials to approved stockpiles without the approval of the Engineer.

Furnish aggregate of the type shown on the plans and listed in Table 1. Use Tex-100-E material definitions.

Table 1
Aggregate Types

| Type | Material |
|---|---|
| A | Gravel, crushed slag, crushed stone, or limestone rock asphalt (LRA) |
| B | Crushed gravel, crushed slag, crushed stone, or LRA |
| C | Gravel, crushed slag, or crushed stone |
| D | Crushed gravel, crushed slag, or crushed stone |
| E | Aggregate as shown on the plans |
| L | Lightweight Aggregate |
| PA | Precoated gravel, crushed slag, crushed stone, or LRA |
| PB | Precoated crushed gravel, crushed slag, crushed stone, or LRA |
| PC | Precoated gravel, crushed slag, or crushed stone |
| PD | Precoated crushed gravel, crushed slag, crushed stone |
| PE | Precoated aggregate as shown on the plans |
| PL | Precoated lightweight aggregate |

Ensure the aggregate gradation meets the requirements in Table 2 for the specified grade, unless otherwise approved.

Furnish aggregate that meets the requirements shown in Table 3, unless otherwise shown on the plans. Furnish LRA in accordance with DMS-9210, "Limestone Rock Asphalt (LRA)," when used. Provide aggregates from sources listed in the Department's *Bituminous Rated Source Quality Catalog* (BRSQC). Use material not listed or not meeting the requirements of the BRSQC only when tested by the Engineer and approved before use. Allow 30 calendar days for testing of material from such sources.

Provide aggregates for final surfaces that meet the SAC shown on the plans. Do not blend to meet the SAC. The SAC requirement will apply only to the aggregate used on the travel lanes unless otherwise shown on the plans. The BRSQC lists the SAC for sources on the *Aggregate Quality Monitoring Program* (AQMP).

Table 2
Aggregate Gradation Requirements (Cumulative % Retained[1])

| Sieve | Grade | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3S[2] | 3 | | 4S[2] | 4 | 5S[2] | 5 |
| | | | | Non-Lightweight | Lightweight | | | | |
| 1" | - | - | - | - | - | - | - | - | - |
| 7/8" | 0–2 | 0 | - | - | - | - | - | - | - |
| 3/4" | 20–35 | 0–2 | 0 | 0 | 0 | - | - | - | - |
| 5/8" | 85–100 | 20–40 | 0–5 | 0–5 | 0–2 | 0 | 0 | - | - |
| 1/2" | - | 80–100 | 55–85 | 20–40 | 10–25 | 0–5 | 0–5 | 0 | 0 |
| 3/8" | 95–100 | 95–100 | 95–100 | 80–100 | 60–80 | 60–85 | 20–40 | 0–5 | 0–5 |
| 1/4" | - | - | - | 95–100 | 95–100 | - | - | 65–85 | - |
| #4 | - | - | - | - | - | 95–100 | 95–100 | 95–100 | 50–80 |
| #8 | 99–100 | 99–100 | 99–100 | 99–100 | 98–100 | 98–100 | 98–100 | 98–100 | 98–100 |

1. Round test results to the nearest whole number.
2. Single-size gradation.

Table 3
Aggregate Requirements

| Property | Test Method | Requirement | Remarks |
|---|---|---|---|
| Sampling | Tex-22-F | - | |
| SAC | AQMP | As shown on the plans | |
| Deleterious Material, %, Max | Tex-217-F, Part I | 2.0 | Not required for lightweight aggregate. |
| Decantation, %, Max | Tex-406-A | 1.5 | |
| Flakiness Index, Max | Tex-224-F | 17 | Unless otherwise shown on the plans. |
| Gradation | Tex-200-F, Part I | See Table 2 | |
| Los Angeles Abrasion, %, Max | Tex-410-A | 35 | |
| Magnesium Sulfate Soundness, 5 Cycle, %, Max | Tex-411-A | 25 | |
| Micro-Deval Abrasion, %, Max | Tex-461-A | – | Not used for acceptance purposes. Used by the Engineer as an indicator for further investigation. |
| Coarse Aggregate Angularity, 2 Crushed Faces, %, Min | Tex-460-A, Part I | 85 | Unless otherwise shown on the plans. Only required for crushed gravel |
| Additional Requirements for Lightweight Aggregate | | | |
| Dry Loose Unit Wt., lb./cu. ft. | Tex-404-A | 35–60 | |
| Pressure Slaking, %, Max | Tex-431-A | 6.0 | |
| Freeze-Thaw Loss, %, Max | Tex-432-A | 10.0 | |
| Water Absorption, 24°hr., %, Max | Tex-433-A | 12.0 | Unless otherwise shown on the plans. |

2.2. Precoating. Precoat aggregate uniformly and adequately with asphalt material to the satisfaction of the Engineer when shown on the plans. Specific aggregates may be prohibited from being precoated when shown on the plans. Meet Table 2 and Table 3 requirements before precoating. Furnish precoated aggregate that spreads uniformly using approved mechanical spreading equipment.

The Engineer retains the right to select a target value for the desired percent by weight of residual bitumen coating on the aggregate. Furnish precoated aggregate that is within ±0.3% of the target value when tested in accordance with Tex-236-F. The Engineer may require trial batches to assist in selecting the target value.

The Engineer retains the right to remove precoat material from aggregate samples in accordance with Tex-236-F and test the aggregate to verify compliance with Table 2 and Table 3 requirements. Gradation testing may be performed with precoat intact.

2.2.1. Asphalt Material. Precoat the aggregates with asphalt material that meets the requirements of Item 300, "Asphalts, Oils, and Emulsions." Use any asphalt material that meets the requirements of Item 300, "Asphalts, Oils, and Emulsions," unless a specific precoat material is specified on the plans.

2.2.2. Additives. Use the type and rate of additive specified when shown on the plans. Add in accordance with Item 301, "Asphalt Antistripping Agents." Use Tex-530-C for verification during production testing unless otherwise directed.

## 3. EQUIPMENT

Manufacture precoated aggregate in a mixing plant that produces uniformly coated aggregate.

## 4. CONSTRUCTION

Deliver aggregate to the locations shown on the plans. Prevent segregation, mixing of the various materials or sizes, and contamination with foreign materials when aggregates are stockpiled. The Engineer will reject contaminated stockpiles.

Provide adequate initial cooling of precoated aggregate to prevent asphalt or aggregate damage due to excessive heat buildup in stockpiles. Limit stockpile height to 3 ft. immediately after production when asphalt cement is the precoating material. Consolidate stockpiles after adequate cooling, as approved. The Engineer will reject stockpiles showing evidence of damage due to excessive heat buildup.

## 5. MEASUREMENT AND PAYMENT

The work performed, materials furnished, equipment, tools, and incidentals will not be measured or paid for directly but is subsidiary to or included under "Payment" in other pertinent Items.

# Item 305

# Salvaging, Hauling, and Stockpiling Reclaimable Asphalt Pavement

## 1. DESCRIPTION

Salvage, haul, and stockpile existing asphalt material.

## 2. CONSTRUCTION

Remove dirt, raised pavement markings, and other debris, as directed. Remove the reclaimable asphalt material as shown on the plans or as directed. Ensure that 95% of the reclaimed material passes a 2 in. sieve unless otherwise shown on the plans. Do not contaminate asphalt material during its removal, transportation, or storage. Repair remaining pavement that is damaged by the removal operations.

Provide a clean, smooth, and well-drained stockpile area free of trash, weeds, and grass. Separate different types or quality of asphalt material into different stockpiles as directed. Stockpile material as shown on the plans or as directed.

The Department retains ownership of the reclaimed asphalt material unless otherwise shown on the plans. The plans or the Engineer may allow or require the use of salvaged material for other items in the Contract. Stockpile the salvaged material at the location shown on the plans or as directed if not used in other construction items of this Contract.

## 3. MEASUREMENT

This Item will be measured by the cubic yard of material calculated by the average end area method in the stockpile, or the square yard in its original position.

## 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 “Salvaging, Hauling, and Stockpiling Reclaimable Asphalt Pavement” for cubic yard measurement, and for “Salvaging, Hauling, and Stockpiling Reclaimable Asphalt Pavement (Depth Specified)” for square yard measurement. This price is full compensation for cleaning and removing existing pavement; stockpile area preparation; loading, crushing or breaking, hauling, and stockpiling material; and material, equipment, labor, tools, supplies, and incidentals.

# Item 310
# Prime Coat

## 1. DESCRIPTION

Prepare and treat existing or newly constructed surface with an asphalt binder or other specialty prime coat binder material. Apply blotter material as required.

## 2. MATERIALS

2.1. Binder. Use material of the type and grade shown on the plans in accordance with Item 300, "Asphalts, Oils, and Emulsions," or as listed in the Department's MPL for prime coat binders.

2.2. Blotter. Use either base course sweepings obtained from cleaning the base or native sand as blotter materials unless otherwise shown on the plans or approved.

## 3. EQUIPMENT

Provide applicable equipment in accordance with Article 316.3., "Equipment."

## 4. CONSTRUCTION

4.1. General. Apply the mixture when the air temperature is at or above 60°F, or above 50°F and rising. Measure the air temperature in the shade away from artificial heat. The Engineer will determine when weather conditions are suitable for application.

Do not permit traffic, hauling, or placement of subsequent courses over freshly constructed prime coats. Maintain the primed surface until placement of subsequent courses or acceptance of the work.

4.2. Surface Preparation. Prepare the surface by sweeping or other approved methods. Lightly sprinkle the surface with water before applying bituminous material, when directed, to control dust and ensure absorption.

4.3. Application.

4.3.1. Binder. The Engineer will select the application temperature within the limits recommended in Item 300, "Asphalts, Oils, and Emulsions," or by the material manufacturer. Apply material within 15°F of the selected temperature but do not exceed the maximum allowable temperature.

Distribute the material smoothly and evenly at the rate selected by the Engineer. Roll the freshly applied prime coat with a pneumatic-tire roller to ensure penetration when directed.

4.3.2. Blotter. Spread blotter material before allowing traffic to use a primed surface. Apply blotter material to primed surface at the specified rate when "Prime Coat and Blotter" is shown on the plans as a bid item or as directed. Apply blotter to spot locations when "Prime Coat" is shown on the plans as a bid item or as directed to accommodate traffic movement through the work area. Remove blotter material before placing the surface. Dispose of blotter material according to applicable state and federal requirements.

## 5. MEASUREMENT

This Item will be measured by the gallon of binder placed and accepted.

## 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 “Prime Coat” or “Prime Coat and Blotter” of the type and grade of binder specified. This price is full compensation for cleaning and sprinkling the area to be primed; materials, including blotter material; and rolling, equipment, labor, tools, and incidentals.

# Item 314
# Emulsified Asphalt Treatment

## 1. DESCRIPTION

Apply an emulsified asphalt and water mixture as a base or subgrade treatment; for erosion control, including dust prevention; or as a prime coat.

## 2. MATERIALS

Furnish materials in accordance with the following.

- Item 204, "Sprinkling"
- Item 300, "Asphalts, Oils, and Emulsions"

Use emulsified asphalt of the type and grade shown on the plans. Use a quantity of emulsified asphalt in the mixture, expressed as a percent of total volume, in accordance with the percentage shown on the plans or as directed.

## 3. EQUIPMENT

Provide a self-propelled sprinkler in accordance with Article 204.3., "Equipment." Provide current calibration documentation for the tank used for distribution.

## 4. CONSTRUCTION

Agitate the water and emulsified asphalt to produce a uniform blend. Evenly distribute at the rate selected by the Engineer to locations shown on the plans or as directed.

4.1. Base or Subgrade Treatment. Treat the base or subgrade to the depth and width shown on the plans or as directed.

Regulate the percentage of emulsified asphalt in the mixture and distribute successive applications to achieve the specified rate. Maintain the proper moisture content of the treated material. Mix the treated material, then shape and compact as required by the specification for the course. Finish the course to the line, grade, and typical section shown on the plans. Maintain the surface with light applications of the emulsified asphalt mixture while curing the course, as directed.

4.2. Erosion Control. Apply the mixture as shown on the plans or as directed.

4.3. Prime Coat. Regulate the percentage of emulsified asphalt in the mixture and distribute successive applications to achieve the specified rate.

## 5. MEASUREMENT

The treatment will be measured by the gallon of emulsified asphalt used in the emulsified asphalt and water mixture.

## 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 “Emulsified Asphalt (Base or Subgrade Treatment),” “Emulsified Asphalt (Erosion Control),” or “Emulsified Asphalt (Prime Coat),” of the type and grade specified. This price is full compensation for materials, including emulsified asphalt and water, and for equipment, labor, tools, and incidentals.

# Item 315
# Fog Seal

## 1. DESCRIPTION

Apply an emulsified asphalt and water mixture as an aggregate loss preventative or surface seal.

## 2. MATERIALS

Use emulsified asphalt of the type and grade shown on the plans that meet the requirements of Item 300, "Asphalts, Oils, and Emulsions." Provide water in accordance with Article 204.2., "Materials."

Use a quantity of emulsified asphalt in the mixture, expressed as a percentage of total volume, which meets the percentage shown on the plans or directed.

## 3. EQUIPMENT

Provide applicable equipment in accordance with Article 316.3., "Equipment." Furnish the necessary facilities and equipment for determining the temperature of the mixture, regulating the application rate, and securing uniformity at the junction of 2 distributor loads.

## 4. CONSTRUCTION

Apply the mixture when the air temperature is at or above 60°F, or above 50°F and rising. Measure the air temperature in the shade away from artificial heat. The Engineer will determine when weather conditions are suitable for application.

The Engineer will select the application temperature within the limits recommended in Item 300, "Asphalts, Oils, and Emulsions." Apply the material within 15°F of the selected temperature but less than the maximum allowable temperature.

Distribute material at the rate shown on the plans or as directed.

Open the treated surface to traffic when directed. Furnish and uniformly distribute clean, fine sand on the surface to blot the excess when an excessive quantity of asphalt is applied. Maintain ingress and egress as directed by applying sand to freshly sealed areas.

## 5. MEASUREMENT

This Item will be measured by the gallon of emulsified asphalt used in the emulsified asphalt and water mixture.

## 6. 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 "Fog Seal" of the type and grade specified. This price is full compensation for materials, equipment, labor, tools, and incidentals. Blotter sand will not be paid for directly but will be subsidiary to this Item.

# Item 316
# Seal Coat

## 1. DESCRIPTION

Construct a surface treatment consisting of one or more applications of a single layer of asphalt material covered with a single layer of aggregate.

## 2. MATERIALS

Furnish materials of the type and grade shown on the plans in accordance with the following:

2.1. **Asphalt**. Furnish asphalt materials meeting the requirements of Item 300, "Asphalts, Oils, and Emulsions."

Furnish Type II or Type III A-R binder in accordance with Section 300.2.9., "Asphalt-Rubber Binders," as shown on the plans. Furnish a blend design for approval. Include in the design, at a minimum, the following:

- manufacturer and grade of asphalt cement;
- manufacturer and grade of crumb rubber;
- manufacturer, type, and percentage of extender oil, if used;
- test report on crumb rubber gradation in accordance with Tex-200-F, Part I;
- design percentage of crumb rubber versus asphalt content;
- blending temperature; and
- test results on the properties at reaction times of 60, 90, 240, 360, and 1,440 min. in accordance with Section 300.2.9., "Asphalt-Rubber Binders."

Furnish a new asphalt-rubber blend design if the grade or source for any of the components changes.

If a tack coat is specified when using asphalt-rubber, unless otherwise shown on the plans or approved, furnish CSS-1H, SS-1H, or a performance grade (PG) binder with a minimum high temperature grade of PG 58 for tack coat binder. Do not dilute emulsified asphalts at the terminal, in the field, or at any other location before use. If required, verify that emulsified asphalt proposed for use meets the minimum residual asphalt percentage specified in Item 300, "Asphalts, Oils, and Emulsions."

2.2. **Aggregate**. Furnish aggregate meeting Item 302, "Aggregates for Surface Treatments," of the type and grade shown on the plans. Unless otherwise shown on the plans, furnish aggregate with a minimum B Surface Aggregate Classification.

2.3. **Materials Selections**. Furnish asphalt and aggregate shown on the plans.

## 3. EQUIPMENT

3.1. **Distributor**. Furnish a distributor that will apply the asphalt material uniformly at the specified rate or as directed.

3.1.1. **Transverse Variable Rate**. When a transverse variable rate is shown on the plans, ensure that the nozzles outside the wheel paths will output a predetermined percentage more asphalt material by volume than the nozzles over the wheel paths. Use a dual spray bar distributor as desired to provide for a transverse variable rate.

3.1.2. **Agitation for Asphalt-Rubber.** If using asphalt-rubber, furnish a distributor capable of keeping the rubber in uniform suspension and adequately mixing the asphalt, rubber, and any additional additives.

3.1.3. **Calibration.**

3.1.3.1. **Transverse Distribution.** Furnish a distributor test report, less than 1 yr. old, when tested in accordance with Tex-922-K, Part III. The Department reserves the right to witness the calibration testing. Notify the Engineer 3 days before calibration testing.

Include the following documentation on the test report:

- the serial number of the distributor,
- a method that identifies the actual nozzle set used in the test, and
- the fan width of the nozzle set at a 12-in. bar height.

When a transverse variable rate is required, and a single spray bar is to be used, perform the test using the type and grade of asphalt material to be used on the project. The Engineer may verify the transverse rate and distribution at any time. If verification does not meet the requirements, correct deficiencies and furnish a new test report.

3.1.3.2. **Tank Volume.** Furnish a volumetric calibration and strap stick for the distributor tank in accordance with Tex-922-K, Part I.

Provide documentation of distributor calibration performed not more than 5 yr. before the date first used on the project. The Engineer may verify calibration accuracy in accordance with Tex-922-K, Part II.

3.1.4. **Computerized Distributor.** When paying for asphalt material by weight, the Engineer may allow use of the computerized distributor display to verify application rates. Verify application rate accuracy at a frequency acceptable to the Engineer.

3.2. **Aggregate Spreader.** Use a continuous-feed, self-propelled spreader to apply aggregate uniformly at the specified rate or as directed. If racked in aggregate is specified on the plans, furnish a second aggregate spreader for the racked in aggregate to apply aggregate uniformly at the specified rate.

3.3. **Rollers.** Unless otherwise shown on the plans, furnish light pneumatic-tire rollers in accordance with Item 210, “Rolling.”

3.4. **Broom.** Furnish rotary, self-propelled brooms.

3.5. **Asphalt Storage and Handling Equipment.** When the plans or the Engineer allows storage tanks, furnish a thermometer in each tank to indicate the asphalt temperature continuously. Keep equipment clean and free of leaks. Keep asphalt material free of contamination.

3.6. **Aggregate Haul Trucks.** Unless otherwise approved, use trucks of uniform capacity to deliver the aggregate. Provide documentation showing measurements and calculation in cubic yards. Clearly mark the calibrated level. Truck size may be limited when shown on the plans.

3.7. **Digital Distance Measuring Instrument.** Furnish a vehicle with a calibrated digital distance measuring instrument accurate to ±6 ft. per mile.

## 4. CONSTRUCTION

4.1. **General.** Comply with the seal coat season as shown on the plans. Asphalt and aggregate rates shown on the plans are for estimating purposes only. Adjust the rates for existing conditions as directed.

4.2. Temporary Aggregate Stockpiles. The Engineer will approve the location of temporary aggregate stockpiles on the right of way before delivery. Place stockpiles in a manner that will not:

- obstruct traffic or sight distance,
- interfere with the access from abutting property, or
- interfere with roadway drainage.

Locate stockpiles a minimum of 30 ft. from roadway when possible. Sign and barricade as shown on the plans.

4.3. Aggregate Furnished by the Department. When shown on the plans, the Department will furnish aggregate to the Contractor without cost. Stockpile locations are shown on the plans.

4.4. Adverse Weather Conditions. Do not place surface treatments when, in the Engineer's opinion, general weather conditions are unsuitable. Meet the requirements for air and surface temperature shown below.

4.4.1. Standard Temperature Limitations. Apply seal coat when air temperature is above 50°F and rising. Do not apply seal coat when air temperature is 60°F and falling. In all cases, do not apply seal coat when surface temperature is below 60°F.

4.4.2. Polymer-Modified Asphalt Cement Temperature Limitations. When using materials described in Section 300.2.2., "Polymer Modified Asphalt Cement," apply seal coat when air temperature is above 70°F and rising. Do not apply seal coat when air temperature is 80°F and falling. In all cases, do not apply seal coat when surface temperature is below 70°F.

4.4.3. Asphalt-Rubber Temperature Limitations. Do not place hot asphalt-rubber seal coat when, in the Engineer's opinion, general weather conditions are unsuitable. Apply seal coat when the air temperature is 80°F and above, or above 70°F and rising. In all cases, do not apply seal coat when surface temperature is below 70°F.

4.4.4. Cool Weather Night Air Temperature. The Engineer reserves the right to review the National Oceanic and Atmospheric Administration (NOAA) weather forecast and determine if the nightly air temperature is suitable for asphalt placement to prevent aggregate loss.

4.4.5. Cold Weather Application. When asphalt application is allowed outside of the above temperature restrictions, the Engineer will approve the binder grade and the air and surface temperatures for asphalt material application. Apply seal coat at air and surface temperatures as directed.

4.5. Mixing Hot A-R Binder. If using asphalt-rubber, mix in accordance with the approved blend design required in Section 316.2.1., "Asphalt."

At the end of each shift, provide the Engineer with production documentation, which includes the following:

- amount and temperature of asphalt cement before addition of rubber,
- amount of rubber and any extender added,
- viscosity of each hot A-R batch just before roadway placement, and
- time of the rubber additions and viscosity tests.

4.6. Surface Preparation. Remove existing raised pavement markers. Repair any damage incurred by removal as directed. Remove dirt, dust, or other harmful material before sealing. When shown on the plans, remove vegetation and blade pavement edges. When directed, apply a tack coat before applying the hot asphalt-rubber treatment on an existing wearing surface in accordance with Section 340.2.5., "Tack Coat."

4.7. Rock Land and Shot.

4.7.1. Definitions.

- A "rock land" is the area covered at the aggregate rate directed with 1 truckload of aggregate.

- A “shot” is the area covered by 1 distributor load of asphalt material.

4.7.2. Setting Lengths. Calculate the lengths of both rock land and shot. Adjust shot length to be an even multiple of the rock land. Verify that the distributor has enough asphalt material to complete the entire shot length. Mark shot length before applying asphalt. When directed, mark length of each rock land to verify the aggregate rate.

4.8. Asphalt Placement.

4.8.1. General. The maximum shot width is the width of the current transverse distribution test required under Section 316.3.1.3.1., “Transverse Distribution,” or the width of the aggregate spreader box, whichever is less. Adjust the shot width so operations do not encroach on traffic or interfere with the traffic control plan, as directed. Use paper or other approved material at the beginning and end of each shot to construct a straight transverse joint and to prevent overlapping of the asphalt. Unless otherwise approved, match longitudinal joints with the lane lines. The Engineer may require a string line if necessary to keep joints straight with no overlapping. Use sufficient pressure to flare the nozzles fully.

Select an application temperature, as approved, in accordance with Item 300, “Asphalts, Oils, and Emulsions.” Uniformly apply the asphalt material at the rate directed, within 15°F of the approved temperature, and not above the maximum allowable temperature.

4.8.2. Limitations. Do not apply asphalt to the roadway until:

- traffic control methods and devices are in place as shown on the plans or as directed,
- the loaded aggregate spreader is in position and ready to begin,
- haul trucks are loaded with enough aggregate to cover the shot area and are in place behind the spreader box, and
- rollers are in place behind the haul trucks.

4.8.3. Nonuniform Application. Stop application if it is not uniform due to streaking, ridging, puddling, or flowing off the roadway surface. Verify equipment condition, operating procedures, application temperature, and material properties. Determine and correct the cause of nonuniform application. If the cause is high or low emulsion viscosity, replace emulsion with material that corrects the problem.

4.8.4. Test Strips. The Engineer may stop asphalt application and require construction of test strips at the Contractor’s expense if any of the following occurs:

- nonuniformity of application continues after corrective action;
- on 3 consecutive shots, application rate differs by more than 0.03 gal. per square yard from the rate directed; or
- any shot differs by more than 0.05 gal. per square yard from the rate directed.

The Engineer will approve the test strip location. The Engineer may require additional test strips until surface treatment application meets specification requirements.

4.9. Aggregate Placement. As soon as possible, apply aggregate uniformly at the rate directed without causing the rock to roll over.

4.9.1. Nonuniform Application. Stop application if it is not uniform in the transverse direction. Verify equipment condition, operating procedures, and transverse application rate. The transverse application rate should be within 1 lb. Determine and correct the cause of nonuniform application.

4.10. Rolling. Start rolling operation on each shot as soon as aggregate is applied. Use sufficient rollers to cover the entire mat width in 1 pass, i.e., 1 direction. Roll in a staggered pattern. Unless otherwise shown on the plans, make a minimum of:

- 5 passes or

- 3 passes when the asphalt material is an emulsion.

If rollers are unable to keep up with the spreader box, stop application until rollers have caught up, or furnish additional rollers. Keep roller tires asphalt-free.

4.11. Patching. Before rolling, repair spots where coverage is incomplete. Repair can be made by hand spotting or other approved method. When necessary, apply additional asphalt material to embed aggregate.

4.12. Racked-in Aggregate. If specified on the plans, apply racked-in aggregate after patching, uniformly at the rate directed. The racked-in aggregate must be applied before opening the roadway or intersection to traffic.

4.13. Brooming. After rolling, sweep as soon as aggregate has sufficiently bonded to remove excess. In areas of racked-in aggregate, sweep as directed.

4.14. Final Acceptance. Maintain seal coat until the Engineer accepts the work. Repair any surface failures. Before final project acceptance, remove all temporary stockpiles and restore the area to the original contour and grade.

## 5. MEASUREMENT

5.1. Asphalt Material. Unless otherwise shown on the plans, asphalt material will be measured by one of the following methods:

5.1.1. Volume. Asphalt material, including all components, will be measured at the applied temperature by strapping the tank before and after road application. The distributor calibrated strap stick will be used for measuring the asphalt level in the distributor asphalt tank. The certified tank chart will be used to determine the beginning gallons and the final gallons in the distributor tank. The quantity to be measured for payment will be the difference between the beginning gallons and the final gallons.

5.1.2. Weight. Asphalt material will be measured in tons using certified scales meeting the requirements of Item 520,"Weighing and Measuring Equipment," unless otherwise approved. The transporting truck must have a seal attached to the draining device and other openings. Random checking on public scales at the Contractor's expense may be required to verify weight accuracy.

Upon work completion or temporary suspension, any remaining asphalt material will be weighed by a certified public weigher, or measured by volume in a calibrated distributor or tank and the quantity converted to tons at the measured temperature. The quantity to be measured will be the number of tons received minus the number of tons remaining after all directed work is complete and minus the amount used for other items.

5.1.3. Quantity Adjustments. When shown on the plans, the measured quantity will be adjusted to compensate for variation in required application or residual rates for different types of asphalt.

5.2. Aggregate. Aggregate will be measured by the cubic yard in the trucks as applied on the road. Strike off the loaded aggregate for accurate measurement when directed.

5.3. Loading, Hauling, and Distributing Aggregate. When the Department furnishes the aggregate, the loading, hauling, and distributing will be measured by the cubic yard in the trucks as applied on the road.

## 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 prices bid for "Asphalt," "Aggregate," and "Loading, Hauling, and Distributing Aggregate" of the types-grades specified on the plans. These prices are full compensation for surface preparation; furnishing, preparing, hauling, and placing materials; removing existing pavement markers and excess aggregate; rolling; cleaning up stockpiles; and equipment, labor, tools, and incidentals.

# Item 320
# Equipment for Asphalt Concrete Pavement

## 1. DESCRIPTION

Provide equipment to produce, haul, place, compact, and core asphalt concrete pavement.

## 2. EQUIPMENT

Ensure weighing and measuring equipment complies with Item 520, "Weighing and Measuring Equipment." Synchronize equipment to produce a mixture meeting the required proportions.

2.1. Production Equipment. Provide:

- drum-mix type, weigh-batch, or modified weigh-batch mixing plants that ensure a uniform, continuous production;
- automatic proportioning and measuring devices with interlock cut-off circuits that stop operations if the control system malfunctions;
- visible readouts indicating the weight or volume of asphalt and aggregate proportions;
- safe and accurate means to take required samples by inspection forces;
- permanent means to check the output of metering devices and to perform calibration and weight checks; and
- additive-feed systems to ensure a uniform, continuous material flow in the desired proportion.

2.1.1. Drum-Mix Plants. Provide a mixing plant that complies with the requirements below.

2.1.1.1. Aggregate Feed System. Provide:

- a minimum of one cold aggregate bin for each stockpile of individual materials used to produce the mix;
- bins designed to prevent overflow of material;
- scalping screens or other approved methods to remove any oversized material, roots, or other objectionable materials;
- a feed system to ensure a uniform, continuous material flow in the desired proportion to the dryer;
- an integrated means for moisture compensation;
- belt scales, weigh box, or other approved devices to measure the weight of the combined aggregate; and
- cold aggregate bin flow indicators that automatically signal interrupted material flow.

2.1.1.2. Reclaimed Asphalt Pavement (RAP) and Recycled Asphalt Shingles (RAS) Feed Systems. Provide a minimum of one bin for each stockpile of RAP and RAS to weigh and feed the recycled material into the hot-mix plant.

2.1.1.3. Mineral Filler Feed System. Provide a closed system for mineral filler that maintains a constant supply with minimal loss of material through the exhaust system. Interlock the measuring device into the automatic plant controls to automatically adjust the supply of mineral filler to plant production and provide a consistent percentage to the mixture.

2.1.1.4. Heating, Drying, and Mixing Systems. Provide:

- a dryer or mixing system to agitate the aggregate during heating;
- a heating system that controls the temperature during production to prevent aggregate and asphalt binder damage;

- a heating system that completely burns fuel and leaves no residue; and
- a recording thermometer that continuously measures and records the mixture discharge temperature.

2.1.1.5. Dust Collection System. Provide a dust collection system to collect fines generated by the drying and mixing process and reintroduce them into the mixing drum.

2.1.1.6. Asphalt Binder Equipment. Supply equipment to heat binder to the required temperature. Equip the heating apparatus with a continuously recording thermometer located at the highest temperature point. Produce a 24-hr. chart of the recorded temperature. Place a device with automatic temperature compensation that accurately meters the binder in the line leading to the mixer.

Furnish a sampling port on the line between the storage tank and mixer. Supply an additional sampling port between any additive blending device and mixer.

Supply an in-line viscosity-measuring device located between the blending unit and the mixing drum when A-R binder is specified. Provide a means to calibrate the meter on site when an asphalt mass flow meter is used.

2.1.1.7. Mixture Storage and Discharge. Provide a surge-storage system to minimize interruptions during operations unless otherwise approved. Furnish a gob hopper or other device to minimize segregation in the bin. Provide an automated system that weighs the mixture upon discharge and produces a ticket showing:

- date,
- project identification number,
- plant identification,
- mix identification,
- vehicle identification,
- total weight of the load,
- tare weight of the vehicle,
- weight of mixture in each load, and
- load number or sequential ticket number for the day.

2.1.1.8. Truck Scales. Provide standard platform scales at an approved location.

2.1.2.1. Screening and Proportioning. Provide enough hot bins to separate the aggregate and to control proportioning of the mixture type specified. Supply bins that discard excessive and oversized material through overflow chutes. Provide safe access for inspectors to obtain samples from the hot bins.

2.1.2.2. Aggregate Weigh Box and Batching Scales. Provide a weigh box and batching scales to hold and weigh a complete batch of aggregate. Provide an automatic proportioning system with low bin indicators that automatically stop when material level in any bin is not enough to complete the batch.

2.1.2.3. Asphalt Binder Measuring System. Provide bucket and scales with enough capacity to hold and weigh binder for one batch.

2.1.2.4. Mixer. Equip mixers with an adjustable automatic timer that controls the dry and wet mixing period and locks the discharge doors for the required mixing period. Furnish a pug mill with a mixing chamber large enough to prevent spillage.

2.1.3.1. Aggregate Feeds. Aggregate control is required at the cold feeds. Hot bin screens are not required.

2.1.3.2. Surge Bins. Provide one or more bins large enough to produce 1 complete batch of mixture.

2.2. Hauling Equipment. Provide trucks with enclosed sides to prevent asphalt mixture loss. Cover each load of mixture with waterproof tarpaulins when shown on the plans or required by the Engineer. Clean all truck beds before use to ensure the mixture is not contaminated. Coat the inside truck beds, when necessary, with an approved release agent from the Department's MPL.

2.3. Placement and Compaction Equipment. Provide equipment that does not damage underlying pavement. Comply with laws and regulations concerning overweight vehicles. Use other equipment that will consistently produce satisfactory results, when approved.

2.3.1. Asphalt Paver. Furnish a paver that will produce a finished surface that meets longitudinal and transverse profile, typical section, and placement requirements. Ensure the paver does not support the weight of any portion of hauling equipment other than the connection. Provide loading equipment that does not transmit vibrations or other motions to the paver that adversely affect the finished pavement quality. Equip the paver with an automatic, dual, longitudinal-grade control system and an automatic, transverse-grade control system.

2.3.1.1. Tractor Unit. Supply a tractor unit that can push or propel vehicles, dumping directly into the finishing machine to obtain the desired lines and grades to eliminate any hand finishing. Equip the unit with a hitch able to maintain contact between the hauling equipment's rear wheels and the finishing machine's pusher rollers while mixture is unloaded.

2.3.1.2. Screed. Provide a heated compacting screed that will produce a finished surface that meets longitudinal and transverse profile, typical section, and placement requirements. Screed extensions must provide the same compacting action and heating as the main unit unless otherwise approved.

2.3.1.3. Grade Reference. Provide a grade reference with enough support that the maximum deflection does not exceed 1/16 in. between supports. Ensure that the longitudinal controls can operate from any longitudinal grade reference including a string line, ski, mobile reference, or joint matching shoes.

2.3.2. Material Transfer Devices. Provide the specified type of device when shown on the plans. Ensure the devices provide a continuous, uniform mixture flow to the asphalt paver. Provide windrow pick-up equipment, when used, constructed to pick up substantially all roadway mixture placed in the windrow.

2.3.3. Remixing Equipment. Provide equipment, when required, that includes a pug mill, variable pitch augers, or variable diameter augers operating under a storage unit with a minimum capacity of 8 tons.

2.3.4. Motor Grader. Provide a self-propelled grader, when allowed, with a blade length of at least 12 ft. and a wheelbase of at least 16 ft.

2.3.5. Thermal Imaging System or Hand-Held Thermal Camera. Provide a thermal imaging system or hand-held thermal camera meeting the requirements of Tex-244-F.

2.3.6. Rollers. Provide rollers meeting the requirements of Item 210, "Rolling," for each type of roller required for compaction.

2.3.7. Straightedges and Templates. Furnish 10-ft. straightedges and other templates as required or approved.

2.5. Coring Equipment. Provide equipment suitable to obtain a pavement specimen meeting the dimensions for testing when coring is required.

## 3. 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 334
# Hot-Mix Cold-Laid Asphalt Concrete Pavement

## 1. DESCRIPTION

Construct a cold-laid pavement layer composed of a compacted mixture of aggregate and asphalt material mixed hot in a mixing plant.

This Item governs mixtures designed for cold placement, defined as placement temperatures below 175°F. If the mixture placement temperature is greater than 175°F, then design, produce, place, and compact the mixture in accordance with the applicable hot-mix asphalt specification.

## 2. MATERIALS

Furnish uncontaminated materials of uniform quality that meet the requirements of the plans and specifications.

Notify the Engineer of all material sources and before changing any material source or formulation. The Engineer will verify that the specification requirements are met when the Contractor makes a source or formulation change, and may require a new laboratory mixture design, trial batch, or both. The Engineer may sample and test project materials at any time during the project.

2.1. Aggregate. Furnish aggregates from sources that conform to the requirements shown in Table 1 and as specified in this Section. Aggregate requirements in this Section, including those shown in Table 1, may be modified or eliminated when shown on the plans. Additional aggregate requirements may be specified when shown on the plans. Provide aggregate stockpiles that meet the definitions in this Section for coarse, intermediate, or fine aggregate. Supply aggregates that meet the definitions in Tex-100-E for crushed gravel or crushed stone. The Engineer will designate the plant or the quarry as the sampling location. Provide samples from materials produced for the project. The Engineer will establish the Surface Aggregate Classification (SAC) and perform Los Angeles abrasion, magnesium sulfate soundness, and Micro-Deval tests. Perform all other aggregate quality tests listed in Table 1. Document all test results on the mixture design report. The Engineer may perform tests on independent or split samples to verify Contractor test results. Stockpile aggregates for each source and type separately. Determine aggregate gradations for mixture design and production testing based on the washed sieve analysis given in Tex-200-F, Part II.

2.1.1. Coarse Aggregate. Coarse aggregate stockpiles must have no more than 20% material passing the No. 8 sieve. Aggregates from sources listed in the Department's *Bituminous Rated Source Quality Catalog* (BRSQC) are preapproved for use. Use only the rated values for hot-mix listed in the BRSQC. Rated values for surface treatment (ST) do not apply to coarse aggregate sources used in hot-mix asphalt.

For sources not listed on the Department's BRSQC:

- build an individual stockpile for each material;
- request the Department test the stockpile for specification compliance; and
- once approved, do not add material to the stockpile unless otherwise approved.

Provide aggregate from non-listed sources only when tested by the Engineer and approved before use. Allow 30 calendar days for the Engineer to sample, test, and report results for non-listed sources.

Provide coarse aggregate with at least the minimum SAC shown on the plans. SAC requirements only apply to aggregates used on the surface of travel lanes. SAC requirements apply to aggregates used on surfaces

other than travel lanes when shown on the plans. The SAC for sources on the Department's *Aggregate Quality Monitoring Program* (AQMP) (Tex-499-A) is listed in the BRSQC.

2.1.1.1. Blending Class A and Class B Aggregates. Class B aggregate meeting all other requirements in Table 1 may be blended with a Class A aggregate to meet requirements for Class A materials. Ensure that at least 50% by weight, or volume if required, of the material retained on the No. 4 sieve comes from the Class A aggregate source when blending Class A and B aggregates to meet a Class A requirement. Blend by volume if the bulk specific gravities of the Class A and B aggregates differ by more than 0.300.

2.1.2. Fine Aggregate. Fine aggregates consist of manufactured sands, screenings, and field sands. Fine aggregate stockpiles must meet the gradation requirements in Table 2. Supply fine aggregates that are free from organic impurities. The Engineer may test the fine aggregate in accordance with Tex-408-A to verify the material is free from organic impurities. No more than 15% of the total aggregate may be field sand or other uncrushed fine aggregate. Use fine aggregate, with the exception of field sand, from coarse aggregate sources that meet the requirements shown in Table 1 unless otherwise approved.

Test the stockpile if 10% or more of the stockpile is retained on the No. 4 sieve, and verify that it meets the requirements in Table 1 for crushed face count (Tex-460-A) and flat and elongated particles (Tex-280-F).

Table 1
Aggregate Quality Requirements

| Property | Test Method | Requirement |
|---|---|---|
| **Coarse Aggregate** | | |
| SAC | Tex-499-A (AQMP) | As shown on the plans |
| Deleterious material, %, Max | Tex-217-F, Part I | 1.5 |
| Decantation, %, Max | Tex-217-F, Part II | 1.5 |
| Micro-Deval abrasion, % | Tex-461-A | Note[1] |
| Los Angeles abrasion, %, Max | Tex-410-A | 40 |
| Magnesium sulfate soundness, 5 cycles, %, Max | Tex-411-A | 30[2] |
| Crushed face count,[3] %, Min | Tex-460-A, Part I | 85 |
| Flat and elongated particles @ 5:1, %, Max | Tex-280-F | 10 |
| **Fine Aggregate** | | |
| Linear shrinkage, %, Max | Tex-107-E | 3 |
| **Combined Aggregates[4]** | | |
| Sand equivalent, %, Min | Tex-203-F | 45 |

1. Not used for acceptance purposes. Used by the Engineer as an indicator of the need for further investigation.
2. Unless otherwise shown on the plans.
3. Only applies to crushed gravel.
4. Aggregates, without mineral filler or additives, combined as used in the job-mix formula (JMF).

Table 2
Gradation Requirements for Fine Aggregate

| Sieve Size | % Passing by Weight or Volume |
|---|---|
| 3/8" | 100 |
| #8 | 70–100 |
| #200 | 0–15 |

2.2. Mineral Filler. Mineral filler consists of finely divided mineral matter such as agricultural lime, crusher fines, hydrated lime, or fly ash. Mineral filler is allowed unless otherwise shown on the plans. Use no more than 2% hydrated lime or fly ashunless otherwise shown on the plans. The plans may require or disallow specific mineral fillers. Provide mineral filler, when used, that:

- is sufficiently dry, free-flowing, and free from clumps and foreign matter as determined by the Engineer;
- does not exceed 3% linear shrinkage when tested in accordance with Tex-107-E; and
- meets the gradation requirements in Table 3.

Table 3
Gradation Requirements for Mineral Filler

| Sieve Size | % Passing by Weight or Volume |
|---|---|
| #8 | 100 |
| #200 | 55–100 |

2.3. Baghouse Fines. Fines collected by the baghouse or other dust-collecting equipment may be reintroduced into the mixing drum.

2.4. Binder Material. Furnish asphalt binder, primer, additives, and water, unless otherwise shown on the plans.

2.4.1. Asphalt Binder. Provide the asphalt shown on the plans, meeting the requirements of Item 300, "Asphalts, Oils, and Emulsions."

2.4.2. Primer. Provide an approved asphalt primer consisting of a blend of asphalt cement and hydrocarbon volatiles.

2.4.3. Water. Provide water that meets the requirements of Item 204, "Sprinkling."

2.4.4. Additives. Use the type and rate of additive specified when shown on the plans. Additives that facilitate mixing or improve the quality of the mixture may be allowed when approved. Provide the Engineer with documentation such as the bill of lading showing the quantity of additives used in the project unless otherwise directed.

When lime or liquid antistripping agents isused, add in accordance with Item 301, "Asphalt Antistripping Agents." Do not add lime directly into the mixing drum of any plant where lime is removed through the exhaust stream unless the plant has a baghouse or dust collection system that reintroduces the lime back into the drum.

2.5. Tack Coat. Furnish CSS-1H, SS-1H, or a performance-graded (PG) binder with a minimum high-temperature grade of PG 58 for tack coat in accordance with Item 300, "Asphalts, Oils, and Emulsions." Specialized or preferred tack coat materials may be allowed or required when shown on the plans. Do not dilute emulsified asphalts at the terminal, in the field, or at any other location before use. The Department may sample the tack coat to verify specification compliance.

## 3. EQUIPMENT

Provide required or necessary equipment in accordance with Item 320, "Equipment for Asphalt Concrete Pavement."

## 4. CONSTRUCTION

Design, produce, store, transport, place, and compact the specified paving mixture in accordance with the requirements of this Item. Provide the mix design unless otherwise shown on the plans. The Department will perform quality assurance (QA) testing. Provide quality control (QC) testing as needed to meet the requirements of this Item.

4.1. Mixture Design.

4.1.1. Design Requirements. Use the typical weight design example given in Tex-204-F, Part I to design a paving mixture that consists of a uniform mixture of aggregate, asphalt material, primer, additives, and water, if allowed, which meets the requirements shown in Tables 4 and 5, unless otherwise shown on the plans. Ensure that the mixture leaves the plant in a workable condition. Provide materials that remain workable in a stockpile for at least 6 mo.

Submit a new mixture design at any time during the project. The Engineer must approve all mixture designs before the Contractor can begin production.

4.1.2. **Job-Mix Formula Approval**. The job-mix formula (JMF) is the combined aggregate gradation and target asphalt percentage used to establish target values for mixture production. JMF1 is the original laboratory mixture design used to produce the trial batch. The Engineer will verify JMF1 based on plant-produced mixture from the trial batch unless otherwise approved. The Engineer may accept an existing mixture design previously used on a Department project and may waive the trial batch to verify JMF1. Provide the Engineer with split samples of the mixtures and blank samples used to determine the ignition oven correction factors. The Engineer will determine the aggregate and asphalt correction factors from the ignition oven using Tex-236-F.

Table 4
Master Gradation Limits (% Passing by Weight or Volume) and VMA Requirments

| Sieve Size | A Coarse Base | B Fine Base | C Coarse Surface | D Fine Surface | F Fine Mixture |
|---|---|---|---|---|---|
| 2" | 100.0[1] | – | – | – | – |
| 1-1/2" | 98.0–100.0 | 100.0[1] | – | – | – |
| 1" | 78.0–94.0 | 98.0–100.0 | 100.0[1] | – | – |
| 3/4" | 64.0–85.0 | 84.0–98.0 | 95.0–100.0 | 100.0[1] | – |
| 1/2" | 50.0–70.0 | – | – | 98.0–100.0 | 100.0[1] |
| 3/8" | – | 60.0–80.0 | 70.0–85.0 | 85.0–100.0 | 98.0–100.0 |
| #4 | 30.0–50.0 | 40.0–60.0 | 43.0–63.0 | 50.0–70.0 | 70.0–90.0 |
| #8 | 22.0–36.0 | 29.0–43.0 | 32.0–44.0 | 35.0–46.0 | 38.0–48.0 |
| #30 | 8.0–23.0 | 13.0–28.0 | 14.0–28.0 | 15.0–29.0 | 12.0–27.0 |
| #50 | 3.0–19.0 | 6.0–20.0 | 7.0–21.0 | 7.0–20.0 | 6.0–19.0 |
| #200 | 2.0–7.0 | 2.0–7.0 | 2.0–7.0 | 2.0–7.0 | 2.0–7.0 |
| Design VMA,[2] % Minimum | | | | | |
| – | 12.0 | 13.0 | 14.0 | 15.0 | 16.0 |
| Production (Plant-Produced) VMA,[2] % Minimum | | | | | |
| – | 11.5 | 12.5 | 13.5 | 14.5 | 15.5 |

1. Defined as maximum sieve size. No tolerance allowed.
2. Voids in mineral aggregates.

Table 5
Laboratory Mixture Design Properties

| Property | Test Method | Requirement |
|---|---|---|
| Target laboratory-molded density, %[1] | Tex-207-F | 92.5 ±1.5 |
| Hveem stability, Min | Tex-208-F | 35 |
| Hydrocarbon-volatile content, %, Max | Tex-213-F | 0.6 |
| Moisture content, %, Max[2] | Tex-212-F | 1.0 |
| Boil test, %, Max[3] | Tex-530-C | 10 |

1. Unless otherwise shown on the plans.
2. Unless otherwise approved.
3. Limit may be increased or eliminated when approved.

4.2. **Production Operations**. Perform a new trial batch when the plant or plant location is changed. Take corrective action and obtain approval to proceed after any production suspension for noncompliance to the specification.

4.2.1. **Stockpiling of Aggregates**. Provide a smooth and well-drained area, cleared of trash, weeds, and grass. Build stockpiles in a manner that will minimize aggregate degradation and segregation. Avoid contamination and mixing of stockpiles. Provide aggregate stockpiles for a minimum of 2 days' production before beginning plant operations. Maintain at least a 2-day aggregate supply through the course of the project unless otherwise directed. Stockpile aggregate for each source and type separately. The Engineer may reject stockpiled materials that come in contact with the earth or other objectionable material.

4.2.2. **Storage and Heating of Asphalt Materials**. Provide enough asphalt material storage capacity to meet the requirements of the plant. Do not heat the asphalt binder above the temperatures specified in Item 300,

"Asphalts, Oils, and Emulsions," or outside the manufacturer's recommended values. Keep all equipment used in the storage and handling of asphalt material clean at all times and operate the equipment in a manner that will prevent contamination with foreign matter.

4.2.3. Storage of the Asphalt Mixture. Store the asphalt mixture in a surge-storage system or in a stockpile. Provide a smooth and well-drained area, cleared of trash, weeds, and grass if the asphalt mixture is stored in a stockpile. Build stockpiles in a manner that will minimize aggregate degradation and segregation. Avoid contamination and mixing of stockpiles.

4.2.4. Mixing and Discharge of Materials. Produce the mixture at a discharge temperature between 145°F and 275°F, as directed. Do not allow the temperature to vary from the selected temperature by more than 25°F. The Department will not pay for or allow placement of any mixture produced above 300°F.

4.2.5. Moisture Content. Furnish the mixture at a moisture content of no more than 1% by weight when discharged from the mixer, unless otherwise shown on the plans or approved. Cease operations at moisture contents above 1% until corrective actions reduce moisture content.

4.3. Hauling Operations. Clean all truck beds before use to ensure mixture is not contaminated. Use a release agent on the Department's MPL to coat truck beds when a release agent is necessary.

4.4. Placement Operations. Prepare the surface by removing raised pavement markers and objectionable material such as moisture, dirt, sand, leaves, and other loose impediments from the surface before placing mixture. Remove vegetation from pavement edges. Place mixture on the road below 175°F. Place the mixture to produce a smooth, finished surface with a uniform appearance and texture that meet typical section requirements. Offset longitudinal joints of successive courses of mixture by at least 6 in. Place mixture so that longitudinal joints on the surface course coincide with lane lines, or as directed. Ensure that all finished surfaces will drain properly.

When desired, dump the asphalt mixture in a windrow and then place in the finishing machine with windrow pickup equipment unless otherwise shown on the plans. Prevent the windrow pickup equipment from contaminating the mixture.

Defer compaction after placing the paving mixture, as directed, to allow for volatilization. Allow the previous course to dry and cure before placing the next course when placing more than one pavement course. Consider the course cured if the hydrocarbon volatile content of the mixture is 0.4% or less by weight of the mixture when tested according to Tex-213-F unless otherwise directed.

Use a motor grader to spread the mixture when shown on the plans or approved. Thoroughly aerate the mixture and spread into place with a power motor grader in a uniform layer. Placement in narrow strips or small irregular areas may require hand spreading.

4.4.1. Weather Conditions. Place the mixture when the roadway surface temperature is 60°F or higher unless otherwise approved. Place mixtures only when weather conditions and moisture conditions of the roadway surface are suitable in the opinion of the Engineer unless otherwise shown on the plans.

4.4.2. Tack Coat. Clean the surface before placing the tack coat. Apply tack coat uniformly at the approved rate unless otherwise directed. The Engineer will set the rate between 0.04 and 0.10 gal. of residual asphalt per square yard of surface area. Apply a thin, uniform tack coat to all contact surfaces of curbs, structures, and joints. Prevent splattering of the tack coat when placed adjacent to curb, gutter, and structures. Roll the tack coat with a pneumatic-tire roller when directed.

4.5. Compaction. Furnish the type, size, and number of rollers required for compaction as approved. Furnish at least one medium pneumatic-tire roller (minimum 12-ton weight). Use the control strip method given in Tex-207-F, Part IV, to establish rolling patterns that achieve maximum compaction. Follow the selected rolling pattern unless changes that affect compaction occur in the mixture or placement conditions. Establish a new rolling pattern when such changes occur. Compact the pavement to the cross-section of the finished paving mixture meeting the requirements of the plans and specifications. Operate vibratory rollers in static

mode when not compacting, changing directions, or when the plan depth of the pavement mat is less than 1-1/2 in. unless otherwise directed.

Start by first rolling the joint with the adjacent pavement and then continue by rolling longitudinally at the sides when rolling with 3-wheel tandem or vibratory rollers. Proceed toward the center of the pavement, overlapping on successive trips by at least 1 ft., unless otherwise directed. Make alternate trips of the roller slightly different in length. Begin rolling at the low side on superelevated curves and progress toward the high side unless otherwise directed.

Avoid displacement of the mixture. Correct any displacement that may occur to the satisfaction of the Engineer. Ensure pavement is fully compacted before allowing rollers to stand on the pavement. Use only water or an approved release agent on rollers, tamps, and other compaction equipment unless otherwise directed. Keep diesel, gasoline, oil, grease, and other foreign matter off the mixture.

Use tamps to thoroughly compact the edges of the pavement along curbs, headers, and similar structures and in locations that will not allow thorough compaction with the rollers. The Engineer may require rolling with a trench roller on widened areas, in trenches, and in other limited areas.

Allow the compacted pavement to cool to 160°F or lower before opening to traffic unless otherwise directed. Sprinkle the finished mat with water or limewater, when directed, to expedite opening the roadway to traffic.

4.6. Production Testing and Operational Tolerances. The aggregate gradation and the asphalt binder content of the produced mixture must not vary from the JMF by more than the percentage point tolerances shown in Table 6. The gradation of the produced mixture may fall outside the master grading limits for any of the sieve sizes from the 1-1/2 in. through the No. 50 sieve if it is within the JMF tolerances. The aggregate gradation of the No. 200 sieve may not exceed the master gradations shown in Table 4. Any sieve size shown in Table 4 with 100% passing requirements will be allowed a 2% tolerance before the material is considered out of specification.

The Engineer may allow alternate methods for determining the asphalt content and aggregate gradation if the aggregate mineralogy is such that Tex-236-F does not yield reliable results. Provide evidence to the Engineer that results from Tex-236-F are not reliable before an alternate method will be allowed. Use the applicable test procedure as directed if an alternate test method is allowed.

Cease production if 3 consecutive tests indicate that the material produced exceeds the tolerances shown in Table 6 for any individual sieve or laboratory-molded density until corrective actions are taken and the results approved. Cease production if 2 consecutive tests indicate that the asphalt binder content tolerances shown in Table 6 are exceeded until corrective actions are taken and the results approved.

Cease production if the Hveem stability shown in Table 5 is not met for 3 consecutive tests until corrective actions are taken and the results approved.

Table 6
Operational Tolerances

| Property | Test Method | Operational Tolerance From JMF |
|---|---|---|
| Individual % retained for sieve sizes smaller than 1-1/2" and larger than #8 | Tex-200-F | ±5.0 |
| Individual % retained for sieve sizes smaller than #8 | | ±3.0 |
| Asphalt binder content, % | Tex-236-F | ±0.3 |
| Laboratory-molded density, % | Tex-207-F | ±1.0 |

4.7. Irregularities. Immediately take corrective action if surface irregularities, including segregation, rutting, raveling, flushing, fat spots, mat slippage, color, texture, roller marks, tears, gouges, streaks, or uncoated aggregate particles are detected. The Engineer may suspend production or placement operations until the problem is corrected.

Remove and replace any mixture that does not bond to the existing pavement or has other surface irregularities identified above at the expense of the Contractor and to the satisfaction of the Engineer.

## 5. MEASUREMENT

This Item will be measured by the ton of composite asphalt concrete mixture of the type used in the completed and accepted work. Measure the weight on scales in accordance with Item 520, "Weighing and Measuring Equipment."

For mixture produced by a weigh-batch plant or a modified weigh-batch plant, measurement will be determined on the batch scales unless surge-storage or stockpiling is used. Keep records of the number of batches, batch design, and the weight of the composite asphalt concrete mixture. The composite asphalt concrete mixture is defined as the asphalt, primer, aggregate, additives, and any residual moisture that is not designated to be deducted. Where surge-storage or stockpiling is used, measurement of the material taken from the surge-storage bin or stockpile will be made on truck scales or suspended hopper scales.

## 6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under Article 334.5., "Measurement," will be paid for at the unit bid price for "Hot-Mix Cold-Laid Asphalt Concrete Pavement" of the mixture type, SAC, and asphalt binder specified.

This price is full compensation for surface preparation, materials including tack coat, placement, equipment, labor, tools, and incidentals.

# Item 340
# Dense-Graded Hot-Mix Asphalt (Small Quantity)

## 1. DESCRIPTION

Construct a hot-mix asphalt (HMA) pavement layer composed of a compacted, dense-graded mixture of aggregate and asphalt binder mixed hot in a mixing plant. This specification is intended for small quantity (SQ) HMA projects, typically under 5,000 tons total production.

## 2. MATERIALS

Furnish uncontaminated materials of uniform quality that meet the requirements of the plans and specifications.

Notify the Engineer of all material sources and before changing any material source or formulation. The Engineer will verify that the specification requirements are met when the Contractor makes a source or formulation change, and may require a new laboratory mixture design, trial batch, or both. The Engineer may sample and test project materials at any time during the project to verify specification compliance in accordance with Item 6, "Control of Materials."

2.1. Aggregate. Furnish aggregates from sources that conform to the requirements shown in Table 1 and as specified in this Section. Aggregate requirements in this Section, including those shown in Table 1, may be modified or eliminated when shown on the plans. Additional aggregate requirements may be specified when shown on the plans. Provide aggregate stockpiles that meet the definitions in this Section for coarse, intermediate, or fine aggregate. Aggregate from reclaimed asphalt pavement (RAP) is not required to meet Table 1 requirements unless otherwise shown on the plans. Supply aggregates that meet the definitions in Tex-100-E for crushed gravel or crushed stone. The Engineer will designate the plant or the quarry as the sampling location. Provide samples from materials produced for the project. The Engineer will establish the Surface Aggregate Classification (SAC) and perform Los Angeles abrasion, magnesium sulfate soundness, and Micro-Deval tests. Perform all other aggregate quality tests listed in Table 1. Document all test results on the mixture design report. The Engineer may perform tests on independent or split samples to verify Contractor test results. Stockpile aggregates for each source and type separately. Determine aggregate gradations for mixture design and production testing based on the washed sieve analysis given in Tex-200-F, Part II.

2.1.1. Coarse Aggregate. Coarse aggregate stockpiles must have no more than 20% material passing the No. 8 sieve. Aggregates from sources listed in the Department's *Bituminous Rated Source Quality Catalog* (BRSQC) are preapproved for use. Use only the rated values for hot-mix listed in the BRSQC. Rated values for surface treatment (ST) do not apply to coarse aggregate sources used in hot-mix asphalt.

For sources not listed on the Department's BRSQC:

- build an individual stockpile for each material;
- request the Department test the stockpile for specification compliance; and
- once approved, do not add material to the stockpile unless otherwise approved.

Provide aggregate from non-listed sources only when tested by the Engineer and approved before use. Allow 30 calendar days for the Engineer to sample, test, and report results for non-listed sources.

Provide coarse aggregate with at least the minimum SAC shown on the plans. SAC requirements only apply to aggregates used on the surface of travel lanes. SAC requirements apply to aggregates used on surfaces other than travel lanes when shown on the plans. The SAC for sources on the Department's *Aggregate Quality Monitoring Program* (AQMP) (Tex-499-A) is listed in the BRSQC.

2.1.1.1. Blending Class A and Class B Aggregates. Class B aggregate meeting all other requirements in Table 1 may be blended with a Class A aggregate to meet requirements for Class A materials. Ensure that at least 50% by weight, or volume if required, of the material retained on the No. 4 sieve comes from the Class A aggregate source when blending Class A and B aggregates to meet a Class A requirement. Blend by volume if the bulk specific gravities of the Class A and B aggregates differ by more than 0.300. Coarse aggregate from RAP and Recycled Asphalt Shingles (RAS) will be considered as Class B aggregate for blending purposes.

The Engineer may perform tests at any time during production, when the Contractor blends Class A and B aggregates to meet a Class A requirement, to ensure that at least 50% by weight, or volume if required, of the material retained on the No. 4 sieve comes from the Class A aggregate source. The Engineer will use the Department's mix design Excel template, when electing to verify conformance, to calculate the percent of Class A aggregate retained on the No. 4 sieve by inputting the bin percentages shown from readouts in the control room at the time of production and stockpile gradations measured at the time of production. The Engineer may determine the gradations based on either washed or dry sieve analysis from samples obtained from individual aggregate cold feed bins or aggregate stockpiles. The Engineer may perform spot checks using the gradations supplied by the Contractor on the mixture design report as an input for the Excel template; however, a failing spot check will require confirmation with a stockpile gradation determined by the Engineer.

2.1.2. Intermediate Aggregate. Aggregates not meeting the definition of coarse or fine aggregate will be defined as intermediate aggregate. Supply intermediate aggregates, when used, that are free from organic impurities.

The Engineer may test the intermediate aggregate in accordance with Tex-408-A to verify the material is free from organic impurities. Supply intermediate aggregate from coarse aggregate sources, when used, that meet the requirements shown in Table 1 unless otherwise approved.

Test the stockpile if 10% or more of the stockpile is retained on the No. 4 sieve, and verify that it meets the requirements in Table 1 for crushed face count (Tex-460-A) and flat and elongated particles (Tex-280-F).

2.1.3. Fine Aggregate. Fine aggregates consist of manufactured sands, screenings, and field sands. Fine aggregate stockpiles must meet the gradation requirements in Table 2. Supply fine aggregates that are free from organic impurities. The Engineer may test the fine aggregate in accordance with Tex-408-A to verify the material is free from organic impurities. No more than 15% of the total aggregate may be field sand or other uncrushed fine aggregate. Use fine aggregate, with the exception of field sand, from coarse aggregate sources that meet the requirements shown in Table 1 unless otherwise approved.

Test the stockpile if 10% or more of the stockpile is retained on the No. 4 sieve, and verify that it meets the requirements in Table 1 for crushed face count (Tex-460-A) and flat and elongated particles (Tex-280-F).

Table 1
Aggregate Quality Requirements

| Property | Test Method | Requirement |
|---|---|---|
| Coarse Aggregate | | |
| SAC | Tex-499-A (AQMP) | As shown on the plans |
| Deleterious material, %, Max | Tex-217-F, Part I | 1.5 |
| Decantation, %, Max | Tex-217-F, Part II | 1.5 |
| Micro-Deval abrasion, % | Tex-461-A | Note[1] |
| Los Angeles abrasion, %, Max | Tex-410-A | 40 |
| Magnesium sulfate soundness, 5 cycles, %, Max | Tex-411-A | 30 |
| Crushed face count,[2] %, Min | Tex-460-A, Part I | 85 |
| Flat and elongated particles @ 5:1, %, Max | Tex-280-F | 10 |
| Fine Aggregate | | |
| Linear shrinkage, %, Max | Tex-107-E | 3 |
| Combined Aggregate[3] | | |
| Sand equivalent, %, Min | Tex-203-F | 45 |

1. Not used for acceptance purposes. Optional test used by the Engineer as an indicator of the need for further investigation.
2. Only applies to crushed gravel.
3. Aggregates, without mineral filler, RAP, RAS, or additives, combined as used in the job-mix formula (JMF).

Table 2
Gradation Requirements for Fine Aggregate

| Sieve Size | % Passing by Weight or Volume |
|---|---|
| 3/8" | 100 |
| #8 | 70–100 |
| #200 | 0–30 |

2.2. Mineral Filler. Mineral filler consists of finely divided mineral matter such as agricultural lime, crusher fines, hydrated lime, or fly ash. Mineral filler is allowed unless otherwise shown on the plans. Use no more than 2% hydrated lime or fly ash unless otherwise shown on the plans. Use no more than 1% hydrated lime if a substitute binder is used unless otherwise shown on the plans or allowed. Test all mineral fillers except hydrated lime and fly ash in accordance with Tex-107-E to ensure specification compliance. The plans may require or disallow specific mineral fillers. Provide mineral filler, when used, that:

- is sufficiently dry, free-flowing, and free from clumps and foreign matter as determined by the Engineer;
- does not exceed 3% linear shrinkage when tested in accordance with Tex-107-E; and
- meets the gradation requirements in Table 3.

Table 3
Gradation Requirements for Mineral Filler

| Sieve Size | % Passing by Weight or Volume |
|---|---|
| #8 | 100 |
| #200 | 55–100 |

2.3. Baghouse Fines. Fines collected by the baghouse or other dust-collecting equipment may be reintroduced into the mixing drum.

2.4. Asphalt Binder. Furnish the type and grade of performance-graded (PG) asphalt specified on the plans.

2.5. Tack Coat. Furnish CSS-1H, SS-1H, or a PG binder with a minimum high-temperature grade of PG 58 for tack coat binder in accordance with Item 300, “Asphalts, Oils, and Emulsions.” Specialized or preferred tack coat materials may be allowed or required when shown on the plans. Do not dilute emulsified asphalts at the terminal, in the field, or at any other location before use.

The Engineer will obtain at least one sample of the tack coat binder per project in accordance with Tex-500-C, Part III, and test it to verify compliance with Item 300, “Asphalts, Oils, and Emulsions.” The Engineer will obtain the sample from the asphalt distributor immediately before use.

2.6. Additives. Use the type and rate of additive specified when shown on the plans. Additives that facilitate mixing, compaction, or improve the quality of the mixture are allowed when approved. Provide the Engineer

with documentation, such as the bill of lading, showing the quantity of additives used in the project unless otherwise directed.

2.6.1. Lime and Liquid Antistripping Agent. When lime or a liquid antistripping agent is used, add in accordance with Item 301, "Asphalt Antistripping Agents." Do not add lime directly into the mixing drum of any plant where lime is removed through the exhaust stream unless the plant has a baghouse or dust collection system that reintroduces the lime into the drum.

2.6.2. Warm Mix Asphalt (WMA). Warm Mix Asphalt (WMA) is defined as HMA that is produced within a target temperature discharge range of 215°F and 275°F using approved WMA additives or processes from the Department's MPL.

WMA is allowed for use on all projects and is required when shown on the plans. When WMA is required, the maximum placement or target discharge temperature for WMA will be set at a value below 275°F.

Department-approved WMA additives or processes may be used to facilitate mixing and compaction of HMA produced at target discharge temperatures above 275°F; however, such mixtures will not be defined as WMA.

2.7. Recycled Materials. Use of RAP and RAS is permitted unless otherwise shown on the plans. Do not exceed the maximum allowable percentages of RAP and RAS shown in Table 4. The allowable percentages shown in Table 4 may be decreased or increased when shown on the plans. Determine asphalt binder content and gradation of the RAP and RAS stockpiles for mixture design purposes in accordance with Tex-236-F. The Engineer may verify the asphalt binder content of the stockpiles at any time during production. Perform other tests on RAP and RAS when shown on the plans. Asphalt binder from RAP and RAS is designated as recycled asphalt binder. Calculate and ensure that the ratio of the recycled asphalt binder to total binder does not exceed the percentages shown in Table 5 during mixture design and HMA production when RAP or RAS is used. Use a separate cold feed bin for each stockpile of RAP and RAS during HMA production.

Surface, intermediate, and base mixes referenced in Tables 4 and 5 are defined as follows:

- Surface. The final HMA lift placed at or near the top of the pavement structure;
- Intermediate. Mixtures placed below an HMA surface mix and less than or equal to 8.0 in. from the riding surface; and
- Base. Mixtures placed greater than 8.0 in. from the riding surface.

2.7.1. RAP. RAP is salvaged, milled, pulverized, broken, or crushed asphalt pavement. Crush or break RAP so that 100% of the particles pass the 2 in. sieve. Fractionated RAP is defined as 2 or more RAP stockpiles, divided into coarse and fine fractions.

Use of Contractor-owned RAP, including HMA plant waste, is permitted unless otherwise shown on the plans. Department-owned RAP stockpiles are available for the Contractor's use when the stockpile locations are shown on the plans. If Department-owned RAP is available for the Contractor's use, the Contractor may use Contractor-owned fractionated RAP and replace it with an equal quantity of Department-owned RAP. This allowance does not apply to a Contractor using unfractionated RAP. Department-owned RAP generated through required work on the Contract is available for the Contractor's use when shown on the plans. Perform any necessary tests to ensure Contractor- or Department-owned RAP is appropriate for use. The Department will not perform any tests or assume any liability for the quality of the Department-owned RAP unless otherwise shown on the plans. The Contractor will retain ownership of RAP generated on the project when shown on the plans.

The coarse RAP stockpile will contain only material retained by processing over a 3/8-in. or 1/2-in. screen unless otherwise approved. The fine RAP stockpile will contain only material passing the 3/8-in. or 1/2-in. screen unless otherwise approved. The Engineer may allow the Contractor to use an alternate to the 3/8-in. or 1/2-in. screen to fractionate the RAP. The maximum percentages of fractionated RAP may be comprised of coarse or fine fractionated RAP or the combination of both coarse and fine fractionated RAP.

Do not use Department- or Contractor-owned RAP contaminated with dirt or other objectionable materials. Do not use Department- or Contractor-owned RAP if the decantation value exceeds 5% and the plasticity index is greater than 8. Test the stockpiled RAP for decantation in accordance with Tex-406-A, Part I. Determine the plasticity index in accordance with Tex-106-E if the decantation value exceeds 5%. The decantation and plasticity index requirements do not apply to RAP samples with asphalt removed by extraction or ignition.

Do not intermingle Contractor-owned RAP stockpiles with Department-owned RAP stockpiles. Remove unused Contractor-owned RAP material from the project site upon completion of the project. Return unused Department-owned RAP to the designated stockpile location.

Table 4
Maximum Allowable Amounts of RAP[1]

| Maximum Allowable Fractionated RAP[2] (%) | | | Maximum Allowable Unfractionated RAP[3] (%) | | |
|---|---|---|---|---|---|
| Surface | Intermediate | Base | Surface | Intermediate | Base |
| 20.0 | 30.0 | 40.0 | 10.0 | 10.0 | 10.0 |

1. Must also meet the recycled binder to total binder ratio shown in Table 5.
2. Up to 5% RAS may be used separately or as a replacement for fractionated RAP.
3. Unfractionated RAP may not be combined with fractionated RAP or RAS.

2.7.2. RAS. Use of post-manufactured RAS or post-consumer RAS (tear-offs) is permitted unless otherwise shown on the plans. Up to 5% RAS may be used separately or as a replacement for fractionated RAP in accordance with Table 4 and Table 5. RAS is defined as processed asphalt shingle material from manufacturing of asphalt roofing shingles or from re-roofing residential structures. Post-manufactured RAS is processed manufacturer's shingle scrap by-product. Post-consumer RAS is processed shingle scrap removed from residential structures. Comply with all regulatory requirements stipulated for RAS by the TCEQ. RAS may be used separately or in conjunction with RAP.

Process the RAS by ambient grinding or granulating such that 100% of the particles pass the 3/8 in. sieve when tested in accordance with Tex-200-F, Part I. Perform a sieve analysis on processed RAS material before extraction (or ignition) of the asphalt binder.

Add sand meeting the requirements of Table 1 and Table 2 or fine RAP to RAS stockpiles if needed to keep the processed material workable. Any stockpile that contains RAS will be considered a RAS stockpile and be limited to no more than 5.0% of the HMA mixture in accordance with Table 4.

Certify compliance of the RAS with DMS-11000, "Evaluating and Using Nonhazardous Recyclable Materials Guidelines." Treat RAS as an established nonhazardous recyclable material if it has not come into contact with any hazardous materials. Use RAS from shingle sources on the Department's MPL. Remove substantially all materials before use that are not part of the shingle, such as wood, paper, metal, plastic, and felt paper. Determine the deleterious content of RAS material for mixture design purposes in accordance with Tex-217-F, Part III. Do not use RAS if deleterious materials are more than 0.5% of the stockpiled RAS unless otherwise approved. Submit a sample for approval before submitting the mixture design. The Department will perform the testing for deleterious material of RAS to determine specification compliance.

2.8. Substitute Binders. Unless otherwise shown on the plans, the Contractor may use a substitute PG binder listed in Table 5 instead of the PG binder originally specified, if the substitute PG binder and mixture made with the substitute PG binder meet the following:

- the substitute binder meets the specification requirements for the substitute binder grade in accordance with Section 300.2.10., "Performance-Graded Binders"; and
- the mixture has less than 10.0 mm of rutting on the Hamburg Wheel test (Tex-242-F) after the number of passes required for the originally specified binder. Use of substitute PG binders may only be allowed at the discretion of the Engineer if the Hamburg Wheel test results are between 10.0 mm and 12.5 mm.

Table 5
Allowable Substitute PG Binders and Maximum Recycled Binder Ratios

| Originally Specified PG Binder | Allowable Substitute PG Binder | Maximum Ratio of Recycled Binder[1] to Total Binder (%) | | |
|---|---|---|---|---|
| | | Surface | Intermediate | Base |
| HMA | | | | |
| 76-22[2] | 70-22 or 64-22 | 20.0 | 20.0 | 20.0 |
| | 70-28 or 64-28 | 30.0 | 35.0 | 40.0 |
| 70-22[2] | 64-22 | 20.0 | 20.0 | 20.0 |
| | 64-28 or 58-28 | 30.0 | 35.0 | 40.0 |
| 64-22[2] | 58-28 | 30.0 | 35.0 | 40.0 |
| 76-28[2] | 70-28 or 64-28 | 20.0 | 20.0 | 20.0 |
| | 64-34 | 30.0 | 35.0 | 40.0 |
| 70-28[2] | 64-28 or 58-28 | 20.0 | 20.0 | 20.0 |
| | 64-34 or 58-34 | 30.0 | 35.0 | 40.0 |
| 64-28[2] | 58-28 | 20.0 | 20.0 | 20.0 |
| | 58-34 | 30.0 | 35.0 | 40.0 |
| WMA[3] | | | | |
| 76-22[2] | 70-22 or 64-22 | 30.0 | 35.0 | 40.0 |
| 70-22[2] | 64-22 or 58-28 | 30.0 | 35.0 | 40.0 |
| 64-22[4] | 58-28 | 30.0 | 35.0 | 40.0 |
| 76-28[2] | 70-28 or 64-28 | 30.0 | 35.0 | 40.0 |
| 70-28[2] | 64-28 or 58-28 | 30.0 | 35.0 | 40.0 |
| 64-28[4] | 58-28 | 30.0 | 35.0 | 40.0 |

1. Combined recycled binder from RAP and RAS.
2. Use no more than 20.0% recycled binder when using this originally specified PG binder.
3. WMA as defined in Section 340.2.6.2., "Warm Mix Asphalt (WMA)."
4. When used with WMA, this originally specified PG binder is allowed for use at the maximum recycled binder ratios shown in this table.

## 3. EQUIPMENT

Provide required or necessary equipment in accordance with Item 320, "Equipment for Asphalt Concrete Pavement."

## 4. CONSTRUCTION

Produce, haul, place, and compact the specified paving mixture. In addition to tests required by the specification, Contractors may perform other QC tests as deemed necessary. At any time during the project, the Engineer may perform production and placement tests as deemed necessary in accordance with Item 5, "Control of the Work." Schedule and participate in a pre-paving meeting with the Engineer on or before the first day of paving unless otherwise directed.

4.1. Certification. Personnel certified by the Department-approved hot-mix asphalt certification program must conduct all mixture designs, sampling, and testing in accordance with Table 6. Supply the Engineer with a list of certified personnel and copies of their current certificates before beginning production and when personnel changes are made. Provide a mixture design developed and signed by a Level 2 certified specialist.

Table 6
Test Methods, Test Responsibility, and Minimum Certification Levels

| Test Description | Test Method | Contractor | Engineer | Level[1] |
|---|---|---|---|---|
| *1. Aggregate and Recycled Material Testing* | | | | |
| Sampling | Tex-221-F | ✓ | ✓ | 1A |
| Dry sieve | Tex-200-F, Part I | ✓ | ✓ | 1A |
| Washed sieve | Tex-200-F, Part II | ✓ | ✓ | 1A |
| Deleterious material | Tex-217-F, Parts I & III | ✓ | ✓ | 1A |
| Decantation | Tex-217-F, Part II | ✓ | ✓ | 1A |
| Los Angeles abrasion | Tex-410-A | | ✓ | TxDOT |
| Magnesium sulfate soundness | Tex-411-A | | ✓ | TxDOT |
| Micro-Deval abrasion | Tex-461-A | | ✓ | 2 |
| Crushed face count | Tex-460-A | ✓ | ✓ | 2 |
| Flat and elongated particles | Tex-280-F | ✓ | ✓ | 2 |
| Linear shrinkage | Tex-107-E | ✓ | ✓ | 2 |
| Sand equivalent | Tex-203-F | ✓ | ✓ | 2 |
| Organic impurities | Tex-408-A | ✓ | ✓ | 2 |
| *2. Asphalt Binder & Tack Coat Sampling* | | | | |
| Asphalt binder sampling | Tex-500-C, Part II | ✓ | ✓ | 1A/1B |
| Tack coat sampling | Tex-500-C, Part III | ✓ | ✓ | 1A/1B |
| *3. Mix Design & Verification* | | | | |
| Design and JMF changes | Tex-204-F | ✓ | ✓ | 2 |
| Mixing | Tex-205-F | ✓ | ✓ | 2 |
| Molding (TGC) | Tex-206-F | ✓ | ✓ | 1A |
| Molding (SGC) | Tex-241-F | ✓ | ✓ | 1A |
| Laboratory-molded density | Tex-207-F | ✓ | ✓ | 1A |
| VMA[2] (calculation only) | Tex-204-F | ✓ | ✓ | 2 |
| Rice gravity | Tex-227-F | ✓ | ✓ | 1A |
| Ignition oven correction factors[3] | Tex-236-F | ✓ | ✓ | 2 |
| Indirect tensile strength | Tex-226-F | ✓ | ✓ | 2 |
| Hamburg Wheel test | Tex-242-F | ✓ | ✓ | 2 |
| Boil test | Tex-530-C | ✓ | ✓ | 1A |
| *4. Production Testing* | | | | |
| Mixture sampling | Tex-222-F | ✓ | ✓ | 1A |
| Molding (TGC) | Tex-206-F | | ✓ | 1A |
| Molding (SGC) | Tex-241-F | | ✓ | 1A |
| Laboratory-molded density | Tex-207-F | | ✓ | 1A |
| VMA[2] (calculation only) | Tex-204-F | | ✓ | 1A |
| Rice gravity | Tex-227-F | | ✓ | 1A |
| Gradation & asphalt binder content[3] | Tex-236-F | | ✓ | 1A |
| Moisture content | Tex-212-F | | ✓ | 1A |
| Hamburg Wheel test | Tex-242-F | | ✓ | 2 |
| Boil test | Tex-530-C | | ✓ | 1A |
| *5. Placement Testing* | | | | |
| Trimming roadway cores | Tex-207-F | ✓ | ✓ | 1A/1B |
| In-place air voids | Tex-207-F | | ✓ | 1A/1B |
| Establish rolling pattern | Tex-207-F | ✓ | | 1B |
| Ride quality measurement | Tex-1001-S | ✓ | ✓ | Note[4] |

1. Level 1A, 1B, and 2 are certification levels provided by the Hot Mix Asphalt Center certification program.
2. Voids in mineral aggregates.
3. Refer to Section 340.4.8.3., "Production Testing," for exceptions to using an ignition oven.
4. Profiler and operator are required to be certified at the Texas A&M Transportation Institute facility when Surface Test Type B is specified.

4.2. Reporting, Testing, and Responsibilities. Use Department-provided Excel templates to record and calculate all test data pertaining to the mixture design. The Engineer will use Department Excel templates for any production and placement testing. Obtain the latest version of the Excel templates at http://www.txdot.gov/inside-txdot/forms-publications/consultants-contractors/forms/site-manager.html or from the Engineer.

The maximum allowable time for the Engineer to exchange test data with the Contractor is as given in Table 7 unless otherwise approved. The Engineer will immediately report to the Contractor any test result that requires suspension of production or placement or that fails to meet the specification requirements.

Subsequent mix placed after test results are available to the Contractor, which require suspension of operations, may be considered unauthorized work. Unauthorized work will be accepted or rejected at the discretion of the Engineer in accordance with Article 5.3., "Conformity with Plans, Specifications, and Special Provisions."

Table 7
Reporting Schedule

| Description | Reported By | Reported To | To Be Reported Within |
|---|---|---|---|
| *Production Testing* | | | |
| Gradation | Engineer | Contractor | 1 working day of completion of the test |
| Asphalt binder content | | | |
| Laboratory-molded density | | | |
| VMA (calculation) | | | |
| Hamburg Wheel test | | | |
| Moisture content | | | |
| Boil test | | | |
| Binder tests | | | |
| *Placement Testing* | | | |
| In-place air voids | Engineer | Contractor | 1 working day of completion of the test[1] |

1. 2 days are allowed if cores cannot be dried to constant weight within 1 day.

4.3. Mixture Design.

4.3.1. Design Requirements. The Contractor may design the mixture using a Texas Gyratory Compactor (TGC) or a Superpave Gyratory Compactor (SGC) unless otherwise shown on the plans. Use the typical weight design example given in Tex-204-F, Part I, when using a TGC. Use the Superpave mixture design procedure given in Tex-204-F, Part IV, when using a SGC. Design the mixture to meet the requirements listed in Tables 1, 2, 3, 4, 5, 8, 9, and 10.

4.3.1.1. Target Laboratory-Molded Density When The TGC Is Used. Design the mixture at a 96.5% target laboratory-molded density. Increase the target laboratory-molded density to 97.0% or 97.5% at the Contractor's discretion or when shown on the plans or specification.

4.3.1.2. Design Number of Gyrations (Ndesign) When The SGC Is Used. Design the mixture at 50 gyrations (Ndesign). Use a target laboratory-molded density of 96.0% to design the mixture; however, adjustments can be made to the Ndesign value as noted in Table 9. The Ndesign level may be reduced to no less than 35 gyrations at the Contractor's discretion.

Use an approved laboratory from the Department's MPL to perform the Hamburg Wheel test in accordance with Tex-242-F, and provide results with the mixture design, or provide the laboratory mixture and request that the Department perform the Hamburg Wheel test. The Engineer will be allowed 10 working days to provide the Contractor with Hamburg Wheel test results on the laboratory mixture design.

The Engineer will provide the mixture design when shown on the plans. The Contractor may submit a new mixture design at any time during the project. The Engineer will verify and approve all mixture designs (JMF1) before the Contractor can begin production.

Provide the Engineer with a mixture design report using the Department-provided Excel template. Include the following items in the report:

- the combined aggregate gradation, source, specific gravity, and percent of each material used;
- asphalt binder content and aggregate gradation of RAP and RAS stockpiles;
- the target laboratory-molded density (or Ndesign level when using the SGC);

- results of all applicable tests;
- the mixing and molding temperatures;
- the signature of the Level 2 person or persons that performed the design;
- the date the mixture design was performed; and
- a unique identification number for the mixture design.

Table 8
Master Gradation Limits (% Passing by Weight or Volume) and VMA Requirements

| Sieve Size | A Coarse Base | B Fine Base | C Coarse Surface | D Fine Surface | F Fine Mixture |
|---|---|---|---|---|---|
| 2" | 100.0[1] | – | – | – | – |
| 1-1/2" | 98.0–100.0 | 100.0[1] | – | – | – |
| 1" | 78.0–94.0 | 98.0–100.0 | 100.0[1] | – | – |
| 3/4" | 64.0–85.0 | 84.0–98.0 | 95.0–100.0 | 100.0[1] | – |
| 1/2" | 50.0–70.0 | – | – | 98.0–100.0 | 100.0[1] |
| 3/8" | – | 60.0–80.0 | 70.0–85.0 | 85.0–100.0 | 98.0–100.0 |
| #4 | 30.0–50.0 | 40.0–60.0 | 43.0–63.0 | 50.0–70.0 | 70.0–90.0 |
| #8 | 22.0–36.0 | 29.0–43.0 | 32.0–44.0 | 35.0–46.0 | 38.0–48.0 |
| #30 | 8.0–23.0 | 13.0–28.0 | 14.0–28.0 | 15.0–29.0 | 12.0–27.0 |
| #50 | 3.0–19.0 | 6.0–20.0 | 7.0–21.0 | 7.0–20.0 | 6.0–19.0 |
| #200 | 2.0–7.0 | 2.0–7.0 | 2.0–7.0 | 2.0–7.0 | 2.0–7.0 |
| Design VMA, % Minimum | | | | | |
| – | 12.0 | 13.0 | 14.0 | 15.0 | 16.0 |
| Production (Plant-Produced) VMA, % Minimum | | | | | |
| – | 11.5 | 12.5 | 13.5 | 14.5 | 15.5 |

1. Defined as maximum sieve size. No tolerance allowed.

Table 9
Laboratory Mixture Design Properties

| Mixture Property | Test Method | Requirement |
|---|---|---|
| Target laboratory-molded density, % (TGC) | Tex-207-F | 96.5[1] |
| Design gyrations (Ndesign for SGC) | Tex-241-F | 50[2] |
| Indirect tensile strength (dry), psi | Tex-226-F | 85–200[3] |
| Boil test[4] | Tex-530-C | – |

1. Increase to 97.0% or 97.5% at the Contractor's discretion or when shown on the plans or specification.
2. Adjust within a range of 35–100 gyrations when shown on the plans or specification or when mutually agreed between the Engineer and Contractor.
3. The Engineer may allow the IDT strength to exceed 200 psi if the corresponding Hamburg Wheel rut depth is greater than 3.0 mm and less than 12.5 mm.
4. Used to establish baseline for comparison to production results. May be waived when approved.

Table 10
Hamburg Wheel Test Requirements

| High-Temperature Binder Grade | Test Method | Minimum # of Passes[1] @ 12.5 mm[2] Rut Depth, Tested @ 50°C |
|---|---|---|
| PG 64 or lower | Tex-242-F | 10,000 |
| PG 70 | | 15,000 |
| PG 76 or higher | | 20,000 |

1. May be decreased or waived when shown on the plans.
2. When the rut depth at the required minimum number of passes is less than 3 mm, the Engineer may require the Contractor to increase the target laboratory-molded density (TGC) by 0.5% to no more than 97.5% or lower the Ndesign level (SGC) to no less than 35 gyrations.

4.3.2. **Job-Mix Formula Approval**. The job-mix formula (JMF) is the combined aggregate gradation, target laboratory-molded density (or Ndesign level), and target asphalt percentage used to establish target values

for hot-mix production. JMF1 is the original laboratory mixture design used to produce the trial batch. When WMA is used, JMF1 may be designed and submitted to the Engineer without including the WMA additive. When WMA is used, document the additive or process used and recommended rate on the JMF1 submittal. Furnish a mix design report (JMF1) with representative samples of all component materials and request approval to produce the trial batch. Provide approximately 10,000 g of the design mixture and request that the Department perform the Hamburg Wheel test if opting to have the Department perform the test. The Engineer will verify JMF1 based on plant-produced mixture from the trial batch unless otherwise determined. The Engineer may accept an existing mixture design previously used on a Department project and may waive the trial batch to verify JMF1. Provide split samples of the mixtures and blank samples used to determine the ignition oven correction factors. The Engineer will determine the aggregate and asphalt correction factors from the ignition oven used for production testing in accordance with Tex-236-F.

The Engineer will use a TGC calibrated in accordance with Tex-914-K in molding production samples. Provide an SGC at the Engineer's field laboratory for use in molding production samples if the SGC is used to design the mix.

The Engineer may perform Tex-530-C and retain the tested sample for comparison purposes during production. The Engineer may waive the requirement for the boil test.

4.3.3. JMF Adjustments. If JMF adjustments are necessary to achieve the specified requirements, the adjusted JMF must:

- be provided to the Engineer in writing before the start of a new lot;
- be numbered in sequence to the previous JMF;
- meet the mixture requirements in Table 4 and Table 5;
- meet the master gradation limits shown in Table 8; and
- be within the operational tolerances of the current JMF listed in Table 11.

The Engineer may adjust the asphalt binder content to maintain desirable laboratory density near the optimum value while achieving other mix requirements.

Table 11
Operational Tolerances

| Description | Test Method | Allowable Difference Between Trial Batch and JMF1 Target | Allowable Difference from Current JMF Target |
|---|---|---|---|
| Individual % retained for #8 sieve and larger | Tex-200-F or Tex-236-F | Must be within master grading limits in Table 8 | ±5.0[1,2] |
| Individual % retained for sieves smaller than #8 and larger than #200 | | | ±3.0[1,2] |
| % passing the #200 sieve | | | ±2.0[1,2] |
| Asphalt binder content, % | Tex-236-F | ±0.5 | ±0.3[2] |
| Laboratory-molded density, % | Tex-207-F | ±1.0 | ±1.0 |
| VMA, %, min | Tex-204-F | Note[3] | Note[3] |

1. When within these tolerances, mixture production gradations may fall outside the master grading limits; however, the % passing the #200 will be considered out of tolerance when outside the master grading limits.
2. Only applies to mixture produced for Lot 1 and higher.
3. Mixture is required to meet Table 8 requirements.

4.4. Production Operations. Perform a new trial batch when the plant or plant location is changed. Take corrective action and receive approval to proceed after any production suspension for noncompliance to the specification. Submit a new mix design and perform a new trial batch when the asphalt binder content of:

- any RAP stockpile used in the mix is more than 0.5% higher than the value shown on the mixture design report; or
- RAS stockpile used in the mix is more than 2.0% higher than the value shown on the mixture design report.

4.4.1. Storage and Heating of Materials. Do not heat the asphalt binder above the temperatures specified in Item 300, "Asphalts, Oils, and Emulsions," or outside the manufacturer's recommended values. Provide the Engineer with daily records of asphalt binder and hot-mix asphalt discharge temperatures (in legible and

discernible increments) in accordance with Item 320, “Equipment for Asphalt Concrete Pavement,” unless otherwise directed. Do not store mixture for a period long enough to affect the quality of the mixture, nor in any case longer than 12 hr. unless otherwise approved.

4.4.2. Mixing and Discharge of Materials. Notify the Engineer of the target discharge temperature and produce the mixture within 25°F of the target. Monitor the temperature of the material in the truck before shipping to ensure that it does not exceed 350°F (or 275°F for WMA) and is not lower than 215°F. The Department will not pay for or allow placement of any mixture produced above 350°F.

Produce WMA within the target discharge temperature range of 215°F and 275°F when WMA is required. Take corrective action any time the discharge temperature of the WMA exceeds the target discharge range. The Engineer may suspend production operations if the Contractor’s corrective action is not successful at controlling the production temperature within the target discharge range. Note that when WMA is produced, it may be necessary to adjust burners to ensure complete combustion such that no burner fuel residue remains in the mixture.

Control the mixing time and temperature so that substantially all moisture is removed from the mixture before discharging from the plant. The Engineer may determine the moisture content by oven-drying in accordance with Tex-212-F, Part II, and verify that the mixture contains no more than 0.2% of moisture by weight. The Engineer will obtain the sample immediately after discharging the mixture into the truck, and will perform the test promptly.

4.5. Hauling Operations. Clean all truck beds before use to ensure that mixture is not contaminated. Use a release agent shown on the Department’s MPL to coat the inside bed of the truck when necessary.

Use equipment for hauling as defined in Section 340.4.6.3.2., “Hauling Equipment.” Use other hauling equipment only when allowed.

4.6. Placement Operations. Collect haul tickets from each load of mixture delivered to the project and provide the Department’s copy to the Engineer approximately every hour, or as directed. Use a hand-held thermal camera or infrared thermometer to measure and record the internal temperature of the mixture as discharged from the truck or Material Transfer Device (MTD) before or as the mix enters the paver and an approximate station number or GPS coordinates on each ticket unless otherwise directed. Calculate the daily yield and cumulative yield for the specified lift and provide to the Engineer at the end of paving operations for each day unless otherwise directed. The Engineer may suspend production if the Contractor fails to produce and provide haul tickets and yield calculations by the end of paving operations for each day.

Prepare the surface by removing raised pavement markers and objectionable material such as moisture, dirt, sand, leaves, and other loose impediments from the surface before placing mixture. Remove vegetation from pavement edges. Place the mixture to meet the typical section requirements and produce a smooth, finished surface with a uniform appearance and texture. Offset longitudinal joints of successive courses of hot-mix by at least 6 in. Place mixture so that longitudinal joints on the surface course coincide with lane lines, or as directed. Ensure that all finished surfaces will drain properly.

Place the mixture at the rate or thickness shown on the plans. The Engineer will use the guidelines in Table 12 to determine the compacted lift thickness of each layer when multiple lifts are required. The thickness determined is based on the rate of 110 lb./sq. yd. for each inch of pavement unless otherwise shown on the plans.

Table 12
Compacted Lift Thickness and Required Core Height

| Mixture Type | Compacted Lift Thickness Guidelines | | Minimum Untrimmed Core Height (in.) Eligible for Testing |
|---|---|---|---|
| | Minimum (in.) | Maximum (in.) | |
| A | 3.00 | 6.00 | 2.00 |
| B | 2.50 | 5.00 | 1.75 |
| C | 2.00 | 4.00 | 1.50 |
| D | 1.50 | 3.00 | 1.25 |
| F | 1.25 | 2.50 | 1.25 |

4.6.1. Weather Conditions. Place mixture when the roadway surface temperature is at or above 60°F unless otherwise approved. Measure the roadway surface temperature with a hand-held thermal camera or infrared thermometer. The Engineer may allow mixture placement to begin before the roadway surface reaches the required temperature if conditions are such that the roadway surface will reach the required temperature within 2 hr. of beginning placement operations. Place mixtures only when weather conditions and moisture conditions of the roadway surface are suitable as determined by the Engineer. The Engineer may restrict the Contractor from paving if the ambient temperature is likely to drop below 32°F within 12 hr. of paving.

4.6.2. Tack Coat. Clean the surface before placing the tack coat. The Engineer will set the rate between 0.04 and 0.10 gal. of residual asphalt per square yard of surface area. Apply a uniform tack coat at the specified rate unless otherwise directed. Apply the tack coat in a uniform manner to avoid streaks and other irregular patterns. Apply a thin, uniform tack coat to all contact surfaces of curbs, structures, and all joints. Allow adequate time for emulsion to break completely before placing any material. Prevent splattering of tack coat when placed adjacent to curb, gutter, and structures. Roll the tack coat with a pneumatic-tire roller to remove streaks and other irregular patterns when directed.

4.6.3. Lay-Down Operations.

4.6.3.1. Windrow Operations. Operate windrow pickup equipment so that when hot-mix is placed in windrows substantially all the mixture deposited on the roadbed is picked up and loaded into the paver.

4.6.3.2. Hauling Equipment. Use belly dumps, live bottom, or end dump trucks to haul and transfer mixture; however, with exception of paving miscellaneous areas, end dump trucks are only allowed when used in conjunction with an MTD with remixing capability unless otherwise allowed.

4.6.3.3. Screed Heaters. Turn off screed heaters, to prevent overheating of the mat, if the paver stops for more than 5 min.

4.7. Compaction. Compact the pavement uniformly to contain between 3.8% and 8.5% in-place air voids.

Furnish the type, size, and number of rollers required for compaction as approved. Use a pneumatic-tire roller to seal the surface unless excessive pickup of fines occurs. Use additional rollers as required to remove any roller marks. Use only water or an approved release agent on rollers, tamps, and other compaction equipment unless otherwise directed.

Use the control strip method shown in Tex-207-F, Part IV, on the first day of production to establish the rolling pattern that will produce the desired in-place air voids unless otherwise directed.

Use tamps to thoroughly compact the edges of the pavement along curbs, headers, and similar structures and in locations that will not allow thorough compaction with rollers. The Engineer may require rolling with a trench roller on widened areas, in trenches, and in other limited areas.

Complete all compaction operations before the pavement temperature drops below 160°F unless otherwise allowed. The Engineer may allow compaction with a light finish roller operated in static mode for pavement temperatures below 160°F.

Allow the compacted pavement to cool to 160°F or lower before opening to traffic unless otherwise directed. Sprinkle the finished mat with water or limewater, when directed, to expedite opening the roadway to traffic.

4.8. Production Acceptance.

4.8.1. Production Lot. Each day of production is defined as a production lot. Lots will be sequentially numbered and correspond to each new day of production. Note that lots are not subdivided into sublots for this specification.

4.8.2. Production Sampling.

4.8.2.1. Mixture Sampling. The Engineer may obtain mixture samples in accordance with Tex-222-F at any time during production.

4.8.2.2. Asphalt Binder Sampling. The Engineer may obtain or require the Contractor to obtain 1 qt. samples of the asphalt binder at any time during production from a port located immediately upstream from the mixing drum or pug mill in accordance with Tex-500-C, Part II. The Engineer may test any of the asphalt binder samples to verify compliance with Item 300, "Asphalts, Oils, and Emulsions."

4.8.3. Production Testing. The Engineer will test at the frequency listed in the Department's *Guide Schedule of Sampling and Testing* and this specification. The Engineer may suspend production if production tests do not meet specifications or are not within operational tolerances listed in Table 11. Take immediate corrective action if the Engineer's laboratory-molded density on any sample is less than 95.0% or greater than 98.0%, to bring the mixture within these tolerances. The Engineer may suspend operations if the Contractor's corrective actions do not produce acceptable results. The Engineer will allow production to resume when the proposed corrective action is likely to yield acceptable results.

The Engineer may use alternate methods for determining the asphalt binder content and aggregate gradation if the aggregate mineralogy is such that Tex-236-F does not yield reliable results. Use the applicable test procedure if an alternate test method is selected.

Table 13
Production and Placement Testing

| Description | Test Method |
|---|---|
| Individual % retained for #8 sieve and larger | Tex-200-F or Tex-236-F |
| Individual % retained for sieves smaller than #8 and larger than #200 | |
| % passing the #200 sieve | |
| Laboratory-molded density | Tex-207-F |
| Laboratory-molded bulk specific gravity | |
| In-Place air voids | |
| VMA | Tex-204-F |
| Moisture content | Tex-212-F, Part II |
| Theoretical maximum specific (Rice) gravity | Tex-227-F |
| Asphalt binder content | Tex-236-F |
| Hamburg Wheel test | Tex-242-F |
| Recycled Asphalt Shingles (RAS)[1] | Tex-217-F, Part III |
| Asphalt binder sampling and testing | Tex-500-C |
| Tack coat sampling and testing | Tex-500-C, Part III |
| Boil test | Tex-530-C |

1. Testing performed by the Construction Division or designated laboratory.

4.8.3.1. Voids in Mineral Aggregates (VMA). The Engineer may determine the VMA for any production lot. Take immediate corrective action if the VMA value for any lot is less than the minimum VMA requirement for production listed in Table 8. Suspend production and shipment of the mixture if the Engineer's VMA result is more than 0.5% below the minimum VMA requirement for production listed in Table 8. In addition to suspending production, the Engineer may require removal and replacement or may allow the lot to be left in place without payment.

4.8.3.2. **Hamburg Wheel Test**. The Engineer may perform a Hamburg Wheel test at any time during production, including when the boil test indicates a change in quality from the materials submitted for JMF1. In addition to testing production samples, the Engineer may obtain cores and perform Hamburg Wheel tests on any areas of the roadway where rutting is observed. Suspend production until further Hamburg Wheel tests meet the specified values when the production or core samples fail the Hamburg Wheel test criteria in Table 10. Core samples, if taken, will be obtained from the center of the finished mat or other areas excluding the vehicle wheel paths. The Engineer may require up to the entire lot of any mixture failing the Hamburg Wheel test to be removed and replaced at the Contractor's expense.

If the Department's or Department-approved laboratory's Hamburg Wheel test results in a "remove and replace" condition, the Contractor may request that the Department confirm the results by re-testing the failing material. The Construction Division will perform the Hamburg Wheel tests and determine the final disposition of the material in question based on the Department's test results.

4.8.4. **Individual Loads of Hot-Mix**. The Engineer can reject individual truckloads of hot-mix. When a load of hot-mix is rejected for reasons other than temperature, contamination, or excessive uncoated particles, the Contractor may request that the rejected load be tested. Make this request within 4 hr. of rejection. The Engineer will sample and test the mixture. If test results are within the operational tolerances shown in Table 11, payment will be made for the load. If test results are not within operational tolerances, no payment will be made for the load.

4.9. **Placement Acceptance**.

4.9.1. **Placement Lot**. A placement lot is defined as the area placed during a production lot (one day's production). Placement lot numbers will correspond with production lot numbers.

4.9.2. **Miscellaneous Areas**. Miscellaneous areas include areas that typically involve significant handwork or discontinuous paving operations, such as temporary detours, driveways, mailbox turnouts, crossovers, gores, spot level-up areas, and other similar areas. Miscellaneous areas also include level-ups and thin overlays when the layer thickness specified on the plans is less than the minimum untrimmed core height eligible for testing shown in Table 12. The specified layer thickness is based on the rate of 110 lb./sq. yd. for each inch of pavement unless another rate is shown on the plans. Compact miscellaneous areas in accordance with Section 340.4.7., "Compaction." Miscellaneous areas are not subject to in-place air void determination except for temporary detours when shown on the plans.

4.9.3. **Placement Sampling**. Provide the equipment and means to obtain and trim roadway cores on site. On site is defined as in close proximity to where the cores are taken. Obtain the cores within one working day of the time the placement lot is completed unless otherwise approved. Obtain two 6-in. diameter cores side-by-side at each location selected by the Engineer for in-place air void determination unless otherwise shown on the plans. For Type D and Type F mixtures, 4-in. diameter cores are allowed. Mark the cores for identification, measure and record the untrimmed core height, and provide the information to the Engineer. The Engineer will witness the coring operation and measurement of the core thickness.

Visually inspect each core and verify that the current paving layer is bonded to the underlying layer. Take corrective action if an adequate bond does not exist between the current and underlying layer to ensure that an adequate bond will be achieved during subsequent placement operations.

Trim the cores immediately after obtaining the cores from the roadway in accordance with Tex-207-F if the core heights meet the minimum untrimmed value listed in Table 12. Trim the cores on site in the presence of the Engineer. Use a permanent marker or paint pen to record the date and lot number on each core as well as the designation as Core A or B. The Engineer may require additional information to be marked on the core and may choose to sign or initial the core. The Engineer will take custody of the cores immediately after they are trimmed and will retain custody of the cores until the Department's testing is completed. Before turning the trimmed cores over to the Engineer, the Contractor may wrap the trimmed cores or secure them in a manner that will reduce the risk of possible damage occurring during transport by the Engineer. After testing, the Engineer will return the cores to the Contractor.

The Engineer may have the cores transported back to the Department's laboratory at the HMA plant via the Contractor's haul truck or other designated vehicle. In such cases where the cores will be out of the Engineer's possession during transport, the Engineer will use Department-provided security bags and the Roadway Core Custody protocol located at http://www.txdot.gov/business/specifications.htm to provide a secure means and process that protects the integrity of the cores during transport.

Instead of the Contractor trimming the cores on site immediately after coring, the Engineer and the Contractor may mutually agree to have the trimming operations performed at an alternate location such as a field laboratory or other similar location. In such cases, the Engineer will take possession of the cores immediately after they are obtained from the roadway and will retain custody of the cores until testing is completed. Either the Department or Contractor representative may perform trimming of the cores. The Engineer will witness all trimming operations in cases where the Contractor representative performs the trimming operation.

Dry the core holes and tack the sides and bottom immediately after obtaining the cores. Fill the hole with the same type of mixture and properly compact the mixture. Repair core holes with other methods when approved.

4.9.4. Placement Testing. The Engineer may measure in-place air voids at any time during the project to verify specification compliance.

4.9.4.1. In-Place Air Voids. The Engineer will measure in-place air voids in accordance with Tex-207-F and Tex-227-F. Cores not meeting the height requirements in Table 12 will not be tested. Before drying to a constant weight, cores may be pre-dried using a Corelok or similar vacuum device to remove excess moisture. The Engineer will use the corresponding theoretical maximum specific gravity to determine the air void content of each core. The Engineer will use the average air void content of the 2 cores to determine the in-place air voids at the selected location.

The Engineer will use the vacuum method to seal the core if required by Tex-207-F. The Engineer will use the test results from the unsealed core if the sealed core yields a higher specific gravity than the unsealed core. After determining the in-place air void content, the Engineer will return the cores and provide test results to the Contractor.

Take immediate corrective action when the in-place air voids exceed the range of 3.8% and 8.5% to bring the operation within these tolerances. The Engineer may suspend operations or require removal and replacement if the in-place air voids are less than 2.7% or greater than 9.9%. The Engineer will allow paving to resume when the proposed corrective action is likely to yield between 3.8% and 8.5% in-place air voids. Areas defined in Section 340.9.2., "Miscellaneous Areas," are not subject to in-place air void determination.

4.9.5. Irregularities. Identify and correct irregularities including segregation, rutting, raveling, flushing, fat spots, mat slippage, irregular color, irregular texture, roller marks, tears, gouges, streaks, uncoated aggregate particles, or broken aggregate particles. The Engineer may also identify irregularities, and in such cases, the Engineer will promptly notify the Contractor. If the Engineer determines that the irregularity will adversely affect pavement performance, the Engineer may require the Contractor to remove and replace (at the Contractor's expense) areas of the pavement that contain irregularities and areas where the mixture does not bond to the existing pavement. If irregularities are detected, the Engineer may require the Contractor to immediately suspend operations or may allow the Contractor to continue operations for no more than one
day while the Contractor is taking appropriate corrective action.

## 5. MEASUREMENT

Hot mix will be measured by the ton of composite hot-mix, which includes asphalt, aggregate, and additives. Measure the weight on scales in accordance with Item 520, “Weighing and Measuring Equipment.”

## 6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under Section 340.5., “Measurement,” will be paid for at the unit bid price for “Dense Graded Hot-Mix Asphalt (SQ)” of the mixture type, SAC, and binder specified. These prices are full compensation for surface preparation, materials including tack coat, placement, equipment, labor, tools, and incidentals.
Trial batches will not be paid for unless they are included in pavement work approved by the Department.

# Item 351
# Flexible Pavement Structure Repair

## 1. DESCRIPTION

Repair localized sections of flexible pavement structure including subgrade, base, and surfacing as shown on the plans.

## 2. MATERIALS

Furnish materials unless otherwise shown on the plans. Provide materials of the type and grade as shown on the plans and in accordance with the following.

- Item 132, “Embankment”
- Item 204, “Sprinkling”
- Item 247, “Flexible Base”
- Item 260, “Lime Treatment (Road-Mixed)”
- Item 310, “Prime Coat”
- Item 316, “Seal Coat”
- Item 334, “Hot-Mix Cold-Laid Asphalt Concrete Pavement”
- Item 340, “Dense Graded Hot-Mix Asphalt (Small Quantity)”

For asphalt concrete materials, Contractor testing and bonus and penalty provisions will be waived unless otherwise shown on the plans.

## 3. EQUIPMENT

Furnish equipment in accordance with pertinent Items. Use of a motor grader will be permitted for asphalt concrete pavement unless otherwise shown on the plans.

## 4. WORK METHODS

Repair using one or more of the following operations as shown on the plans. For Contracts with callout work, begin physical repair within 24 hr. of notification unless otherwise shown on the plans. Cut neat vertical faces around the perimeter of the work area when removing pavement structure layers. Removed materials are the property of the Contractor unless otherwise shown on the plans. Dispose of removed material in accordance with federal, state, and local regulations. Provide a smooth line and grade conforming to the adjacent pavement.

4.1. Removing Pavement Structure. Remove adjacent soil and vegetation if necessary to prevent contamination of the repair area, and place it in a windrow. Do not damage adjacent pavement structure during repair operations. Remove flexible pavement structure layers from work area if subgrade work is required.

4.2. Preparing Subgrade. Fill holes, ruts, and depressions with approved material. Wet, reshape, and compact the subgrade thoroughly as directed.

Remove unstable subgrade material to the depth directed and replace with an approved material where subgrade has failed.

4.3. Mixing and Placing Base Material. Place, spread, and compact material in accordance with the applicable Item to the required or directed depth. Pulverize bituminous material to a maximum dimension of 2-1/2 in. and uniformly mix with existing base to the depth shown on the plans when the material is to remain in pavement structure.

4.3.1. Flexible Base. Use existing base and add new flexible base as required in accordance with Item 247, "Flexible Base," and details shown on the plans to achieve required section.

4.3.2. Lime-Stabilized Base. Use existing base, add new flexible base, and stabilize with a minimum lime content of 3% by weight of the total mixture. Construct in accordance with Item 260, "Lime Treatment (Road-Mixed),and details shown on the plans to achieve required section.

4.3.4. Asphalt-Stabilized Base. Place asphalt-stabilized base in accordance with Item 340, "Dense-Graded Hot-Mix Asphalt (Small Quantity)," and details shown on the plans to achieve required section.

4.4. Curing Base. Cure in accordance with the appropriate Item unless otherwise directed or approved. Maintain completed base sections until surfacing.

4.5. Surfacing. Apply surfacing with materials as shown on the plans to the completed base section.

4.5.1. Prime Coat. Protect the compacted, finished, and cured flexible, lime-stabilized, or cement-stabilized base mixtures with a prime coat of the type and grade shown on the plans. Apply the prime coat at the rate shown on the plans.

4.5.2. Surface Treatments. Apply surface treatment with the type and grade of asphalt and aggregate as shown on the plans in accordance with Item 316, "Seal Coat."

4.5.3. Asphalt Concrete Pavement. Apply tack coat of the type and grade and at the rate shown on the plans unless otherwise directed. Construct in accordance with Item 334, "Hot-Mix Cold-Laid Asphalt Concrete Pavement," or Item 340, "Dense-Graded Hot-Mix Asphalt (Small Quantity)," to achieve required section.

4.6. Finishing. Regrade and compact disturbed topsoil. Clean roadway surface after repair operations.

## 5. MEASUREMENT

This Item will be measured by the square yard. In areas where material is excavated, as directed, to depths greater than those specified on the plans, measurement will be made by dividing the actual depth of such area by the plan depth and then multiplying this figure by the area in square yard of work performed. Calculations for each repaired area will be rounded up to the nearest 1/10 sq. yd. At each repair location, the minimum area for payment purposes will be 1 sq. yd.

The minimum quantity for Contracts with callout work is 5 sq. yd. per callout unless otherwise 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 “Flexible Pavement Structure Repair” of the specified depth. This price is full compensation for scarifying, removing, hauling, spreading, disposing of, and stockpiling existing pavement structure; removing objectionable or unstable material; furnishing and placing materials; maintaining completed section before surfacing; applying tack or prime coat; hauling, sprinkling, spreading, and compacting; and equipment, labor, tools, and incidentals.

# Item 354
# Planing and Texturing Pavement

## 1. DESCRIPTION

Plane, or plane and texture, existing asphalt concrete pavement, asphalt-stabilized base, or concrete pavement. Texture bridge deck surfaces.

## 2. EQUIPMENT

The Engineer may require demonstration of the equipment's capabilities.

2.1. Planing Machine. Use planing machines that:

- have a minimum 6-ft. cutting width except for work areas less than 6 ft. wide;
- are self-propelled with enough power, traction, and stability to maintain an accurate depth of cut and slope;
- can cut in one continuous operation: 4 in. of asphalt concrete pavement, 1 in. of concrete pavement, or a combination of 2 in. of asphalt concrete pavement and 1/2 in. of concrete pavement;
- use dual longitudinal controls capable of operating on both sides automatically from any longitudinal grade reference, which includes string line, ski, mobile string line, or matching shoe;
- use transverse controls with an automatic system to control cross slope at a given rate;
- use integral loading and reclaiming devices to allow cutting, removal, and discharge of the material into a truck in one operation; and
- include devices to control dust created by the cutting action.

2.2. Manual System. Use a manual system that can achieve a uniform depth of cut, flush to all inlets, valve covers, manholes, and other appurtenances within the paved area. Use of a manual system is allowed for areas restricted to self-propelled access and for detail pavement removal.

2.3. Sweeper. Use a street sweeper to remove cuttings and debris from the planed or textured pavement unless otherwise approved. Equip the sweeper with a water tank, dust control spray assembly, both a pick-up and a gutter broom, and a debris hopper.

## 3. CONSTRUCTION

3.1. Grade Reference. Place grade reference points at maximum intervals of 50 ft. in accordance with Item 5, "Control of the Work," when required. Use the control points to set the grade reference. Support the grade reference so the maximum deflection does not exceed 1/16 in. between supports.

3.2. Planing and Texturing. Vary the speed of the machine to leave a grid or other pattern type with discontinuous longitudinal reach. Remove the pavement surface for the length, depth, and width shown on the typical section and to the established line and grades. Remove pavement to vertical lines adjacent to curbs, gutters, inlets, manholes, or other obstructions. Do not damage appurtenances or underlying pavement. Provide a planed surface that has a uniform textured appearance and riding surface. Surface should be free from gouges, continuous longitudinal grooves, ridges, oil film, and other imperfections of workmanship. Leave a uniform surface of concrete pavement free of asphalt materials when removing an asphalt concrete pavement overlay.

Provide a minimum texture depth of not less than 0.05 in. when an overlay on the planed pavement is not required. Stop planing operations when surface texture depth is not sufficient. Plane no more than 3/16 in.

into the original deck surface on bridges. Never damage armor joints, sealed expansion joints, and other appurtenances.

Provide a pavement surface that, after planing, has a smooth riding quality and is true to the established line, grade, and cross-section. Provide a pavement surface that does not vary more than 1/8 in. in 10 ft. Evaluate this criterion with a 10-ft. straightedge placed parallel to the centerline of the roadway. Deviations will be measured from the top of the texture. Correct any point in the surface not meeting this requirement.

Sweep pavement and gutter. Leave pavement and curb clean.

3.3. Edge Treatments. Slope vertical or near vertical longitudinal faces in the pavement surface for areas under traffic in accordance with the requirements on the plans at the end of the day. Taper transverse faces to provide an acceptable ride.

3.4. Salvaged Materials. The Department will retain ownership of planed materials unless otherwise shown on the plans. Stockpile salvaged materials at locations shown on the plans. Prepare the stockpile site by removing vegetation and trash and providing proper drainage. Keep salvaged paving material free from contamination during its removal, transportation, and storage. Place different types or quality of salvaged asphalt paving material into separate stockpiles. Dispose of unsalvageable material in accordance with applicable federal, state, and local regulations.

## 4. MEASUREMENT

This Item will be measured by the square yard of surface area for each pavement type including asphalt concrete pavement, concrete pavement, and bridge decks. Measurement will be based on the depth shown for each bid item, within the limits shown on the plans, regardless of the number of passes required. Only
1 bid item for each pavement type will apply to any 1 location.

## 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 “Planing and Texturing Asphalt Concrete Pavement,” “Planing and Texturing Concrete Pavement,” “Planing Asphalt Concrete Pavement,” or “Planing Concrete Pavement” of the depths specified, and for “Texturing Bridge Decks.”

The planing of concrete pavement to remove all asphalt concrete pavement as required under Article 354.3.,“Construction,” is subsidiary to the planing of asphalt concrete pavement of the depth shown on the plans.

This price is full compensation for removing all material to the depth shown; texturing the pavement surface when texturing is shown in the bid item description; loading, hauling, and unloading; stockpiling or disposing of material; sweeping; tapering or sloping longitudinal or transverse joints as described under Section 354.3.3., “Edge Treatments”; and equipment, labor, tools, and incidentals. Demonstration work to receive approval for use of equipment will not be paid for unless work is performed in accordance with the Contract and is accepted.

# 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. of cementitious material.

Use coarse aggregates for continuously reinforced concrete pavements to produce concrete with a coefficient of thermal expansion not more than $5.5 \times 10^{-6}$ 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 $5.5 \times 10^{-6}$ 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 for curbs that are placed separately from the pavement. Provide concrete that is workable and cohesive, possesses satisfactory finishing qualities, and conforms to the mix design and mix design slump.

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 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.

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. Provide adequate illumination for nighttime sawing.

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 |
|---|---|
| | |
| | |
| 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. Repair excess*ive 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. 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.

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.

4.9.4. Curing Fast-Track Concrete. Provide wet mat curing unless otherwise shown on the plans or as directed. 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 each lane 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.

## 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 400
# Excavation and Backfill for Structures

## 1. DESCRIPTION

Excavate for placement and construction of structures and backfill structures. Cut and restore pavement.

## 2. MATERIALS

Use materials that meet the requirements of the following Items.

- Item 421, “Hydraulic Cement Concrete”
- DMS-4600, “Hydraulic Cement”

## 3. CONSTRUCTION

3.1. Excavation.

3.1.1. General. Excavate to the lines and grades shown on the plans or as directed. Provide slopes, benching, sheeting, bracing, pumping, and bailing as necessary to maintain the stability and safety of excavations up to 5 ft. deep. Excavation protection for excavations deeper than 5 ft. are governed by Item 402, “Trench Excavation Protection. Use satisfactory excavated material as backfill or as embankment fill in accordance with Item 132, “Embankment.” Dispose of material not incorporated into the final project off the right of way in accordance with federal, state, and local regulations.

Keep any topsoil that has been removed separate, and replace it, as nearly as feasible, in its original position when excavating for installation of structures across private property or beyond the limits of the embankment. Restore the area to an acceptable condition.

Excavate drilled shafts in accordance with Item 416, “Drilled Shaft Foundations.”

3.1.1.1. Obstructions. Remove obstructions to the proposed construction, including trees and other vegetation, debris, and structures, over the width of the excavation to a depth of 1 ft. below the bottom of excavation. Remove as required to clear the new structure and plug in an approved manner if abandoned storm drains, sewers, or other drainage systems are encountered. Restore the bottom of the excavation to grade by backfilling after removing obstructions in accordance with this Item. Dispose of surplus materials in accordance with federal, state, and local regulations.

3.1.1.2. Excavation in Streets. Cut pavement and base to neat lines when structures are installed in streets, highways, or other paved areas. Restore pavement structure after completion of excavation and backfilling.

Maintain and control traffic in accordance with the approved traffic control plan and the TMUTCD.

3.1.1.3. Utilities. Comply with the requirements of Article 7.19., “Responsibility for Damage Claims.” Conduct work with minimum disturbance of existing utilities, and coordinate work in or near utilities with the utility owners. Inform utility owners before work begins, allowing them enough time to identify, locate, reroute, or make other adjustments to utility lines.

Avoid cutting or damaging underground utility lines that are to remain in place. Promptly notify the utility company if damage occurs. Provide temporary flumes across the excavation while open if an active sanitary

sewer line is damaged during excavation, and restore the lines when backfilling has progressed to the original bedding lines of the cut sewer.

3.1.1.4. De-Watering. Construct or place structures in the presence of water only if approved. Place precast members, pipe, and concrete only on a dry, firm surface. Remove water by bailing, pumping, well-point installation, deep wells, underdrains, or other approved method.

Remove standing water in a manner that does not allow water movement through or alongside concrete being placed if structures are approved for placement in the presence of water. Pump or bail only from a suitable sump separated from the concrete work while placing structural concrete or for a period of at least 36 hr. thereafter. Pump or bail during placement of seal concrete only to the extent necessary to maintain a static head of water within the cofferdam. Pump or bail to de-water inside a sealed cofferdam only after the seal has aged at least 36 hr.

Place a stabilizing material in the bottom of the excavation if the bottom of an excavation cannot be de-watered to the point the subgrade is free of mud or it is difficult to keep reinforcing steel clean. Use flexible base, cement-stabilized base or backfill, lean concrete, or other approved stabilizing material. Provide concrete with at least 275 lb. of cement per cubic yard, if lean concrete is used, and place to a minimum depth of 3 in. Stabilizing material placed for the convenience of the Contractor will be at the Contractor's expense.

3.1.2. Bridge Foundations and Retaining Walls. Do not disturb material below the bottom of footing grade. Do not backfill to compensate for excavation that has extended below grade. Fill the area with concrete at the time the footing is placed if excavation occurs below the proposed footing grade. Additional concrete placed will be at the Contractor's expense.

Take core samples to determine the character of the supporting materials if requested. Provide an intact sample adequate to judge the character of the founding material. Take these cores when the excavation is close to completion. Cores should be approximately 5 ft. deeper than the proposed founding grade.

Remove loose material if the founding stratum is rock or another hard material, and clean and cut it to a firm surface that is level, stepped, or serrated, as directed. Clean out soft seams, and fill with concrete at the time the footing is placed.

Place the foundation once the Engineer has inspected the excavation and authorized changes have been made to provide a uniform bearing condition if the material at the footing grade of a retaining wall, bridge bent, or pier is a mixture of compressible and incompressible material.

3.1.3. Cofferdams. The term "cofferdam" designates any temporary or removable structure constructed to hold surrounding earth, water, or both out of the excavation whether the structure is formed of soil, timber, steel, concrete, or a combination of these. Use pumping wells or well points for de-watering cofferdams if required.

Submit details and design calculations for sheet-pile or other types of cofferdams requiring structural members bearing the seal of a licensed professional engineer for review before constructing the cofferdam. The Department reserves the right to reject designs. Design structural systems to comply with the AASHTO *Standard Specifications for Highway Bridges* or AASHTO LRFD *Bridge Design Specifications*. Interior dimensions of cofferdams must provide enough clearance for the construction, inspection, and removal of required forms and, if necessary, enough room to allow pumping outside the forms. Extend sheet-pile cofferdams well below the bottom of the footings, and make concrete seals as well braced and watertight as practicable.

Use Class E concrete for foundation seals unless otherwise specified. Place concrete foundation seals in accordance with Item 420, "Concrete Substructures." Seals placed for the convenience of the Contractor will be at the Contractor's expense.

Make the excavation deep enough to allow for swelling of the material at the base of the excavation during pile-driving operations when the Engineer judges it to be impractical to de-water inside a cofferdam and a

concrete seal is to be placed around piling driven within the cofferdam. Remove swelling material to the bottom of the seal grade after driving the piling. Remove the foundation material to exact footing grades where it is possible to de-water inside the cofferdam without placing a seal after driving piling. Do not backfill a foundation to compensate for excavation that has been extended below grade; fill such areas below grade with concrete at the time the seals or footings are placed.

Remove cofferdams after completing the substructure without disturbing or damaging the structure unless otherwise provided.

3.1.4. Culverts and Storm Drains. When the design requires special bedding conditions for culverts or storm drains, an excavation diagram will be shown on the plans. Do not exceed these limits of excavation.

Construct pipe structures in an open cut with vertical sides extending to a point 1 ft. above the pipe unless otherwise shown on the plans. When site conditions or the plans do not prohibit sloping the cut, the excavation may be stepped or laid back to a stable slope beginning 1 ft. above the pipe. Maintain the stability of the excavation throughout the construction period.

Construct the embankment for pipe to be installed in fill above natural ground to an elevation at least 1 ft. above the top of the pipe, and then excavate for the pipe.

3.1.4.1. Unstable Material. Remove the material to a depth of no more than 2 ft. below the grade of the structure when unstable soil is encountered at established footing grade, unless the Engineer authorizes additional depth. Replace soil removed with stable material in uniform layers no greater than 8 in. deep (loose measurement). Each layer must have enough moisture to be compacted by rolling or tamping as required to provide a stable foundation for the structure.

Use special materials such as flexible base, cement-stabilized base, cement-stabilized backfill, or other approved material when it is not feasible to construct a stable foundation as outlined above.

3.1.4.2. Incompressible Material. Remove the incompressible material to 6 in. below the footing grade, backfill with an approved compressible material, and compact in accordance with Section 400.3.3., “Backfill,” if rock, part rock, or other incompressible material is encountered at established footing grade while placing prefabricated elements.

3.2. Shaping and Bedding. Place at least 2 in. of fine granular material for precast box sections on the base of the excavation before placing the box sections. Use bedding as shown in Figure 1 for pipe installations. Use Class C bedding unless otherwise shown on the plans. The Engineer may require the use of a template to secure reasonably accurate shaping of the foundation material. Undercut the excavation at least 4 in. where cement-stabilized backfill is indicated on the plans and backfill with stabilized material to support the pipe or box at the required grade.

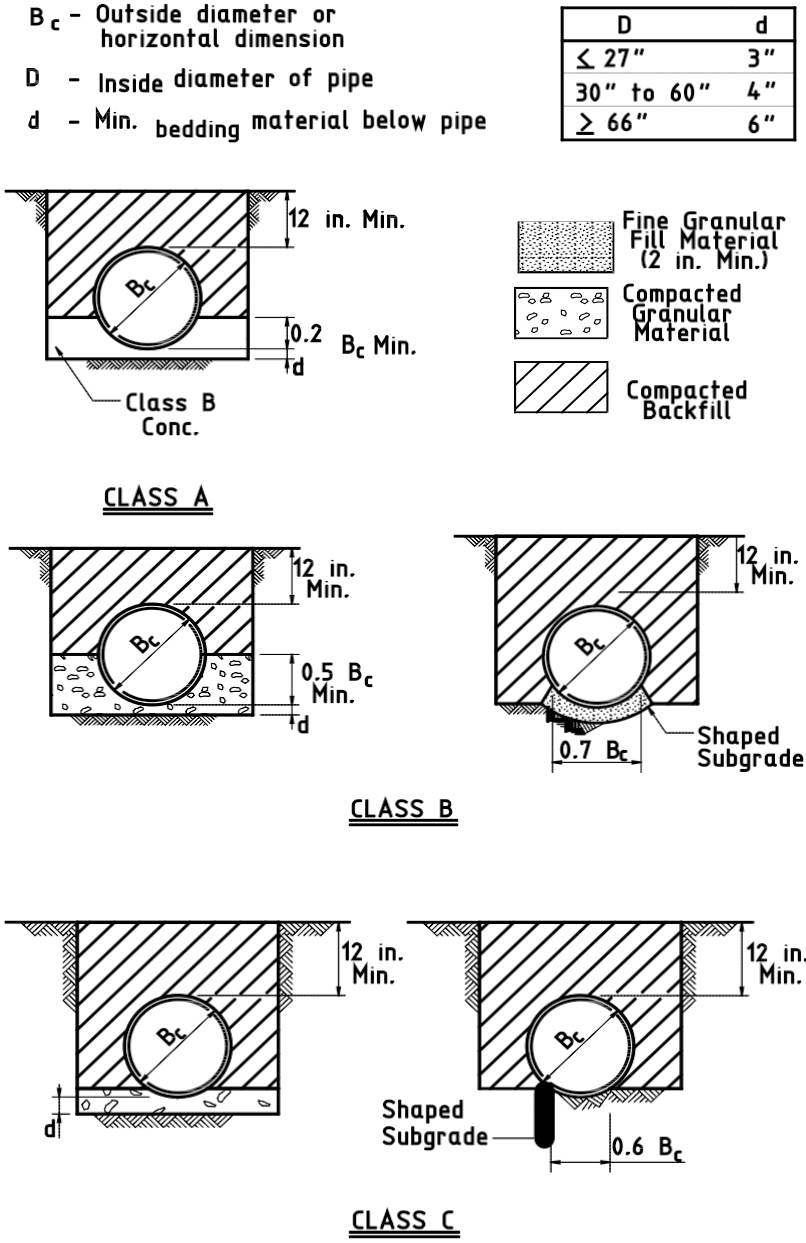


Figure 1
Bedding Diagrams

3.3. Backfill.

3.3.1. General. Backfill the excavation after placement of the permanent structure as soon as practical. Use backfill free from stones large enough to interfere with compaction; large or frozen lumps that will not break down readily under compaction; and wood or other extraneous material. Obtain backfill material from excavation or from other sources.

Place backfill in layers no greater than 10 in. deep (loose measurement) in areas not supporting a completed roadbed, retaining wall, or embankment. Place backfill in uniform layers no greater than 8 in. deep (loose measurement) in areas supporting a portion of a roadbed, retaining wall, or embankment. Compact each layer to meet the density requirements of the roadbed, retaining wall, embankment material, or as shown on the plans.

Bring each layer of backfill material to the moisture content needed to obtain the required density. Use mechanical tamps or rammers to compact the backfill. Rollers may be used to compact backfill if feasible.

Cohesionless materials may be used for backfilling. Use cohesionless materials that conform to the requirements of Table 1.

Table 1
Cohesionless Material Gradation Limits

| Sieve Size | Percent Retained |
|---|---|
| 3" | 0 |
| #10 | See Note[1] |
| #200 | 90–100 |

1. No. 10 sieve requirements are 0 to 30% retained when used as aggregate for cement-stabilized backfill.

Compact cohesionless materials using vibratory equipment, water-ponding, or a combination of both.

3.3.2. Bridge Foundations, Retaining Walls, Manholes/Inlets, and Box Culverts. Place backfill against the structure only after the concrete has reached the design strength required in Item 421, "Hydraulic Cement Concrete."

Backfill retaining walls with material meeting the requirements of Item 423, "Retaining Walls." Backfill around bridge foundations, manholes/inlets and culverts using material with particles no more than 4 in. in greatest dimension and a gradation that permits thorough compaction. Use rock or gravel mixed with soil if the percentage of fines is enough to fill all voids and ensure a uniform and thoroughly compacted mass of proper density.

Use mechanical tamps and rammers to avoid damage to the structure where backfill material is being placed too close to the structure to permit compaction with blading and rolling equipment.

Avoid wedging action of backfill against structures. Step or serrate slopes bounding the excavation to prevent such action. Place backfill uniformly around bridge foundations. Place backfill equally and in uniform layers along both sides of manholes/inlets and culverts.

The Engineer may require backfilling of structures excavated into hard, erosion-resistant material, and subject to erosive forces, with stone or lean concrete.

Box culverts may be opened to traffic as soon as enough backfill and embankment has been placed over the top to protect culverts against damage from heavy construction equipment. Repair damage to culvert caused by construction traffic at no additional expense to the Department.

3.3.3. Pipe. Bring backfill material to the proper moisture condition after installing bedding and pipe as required and place it equally along both sides of the pipe in uniform layers no greater than 8 in. deep (loose measurement). Compact each lift mechanically. Thoroughly compact materials placed under the haunches of the pipe to prevent damage or displacement of the pipe. Place backfill in this manner to the top-of-pipe elevation. Place and compact backfill above the top of the pipe in accordance with Section 400.3.3.1., "General."

The Engineer may reject backfill material containing more than 20% by weight of material retained on a 3 in. sieve with large lumps not easily broken down or that cannot be spread in loose layers. Material excavated by a trenching machine will generally meet the requirements of this Section as long as large stones are not present.

Place and compact additional material where pipe extends beyond the toe of slope of the embankment and the depth of cover provided by backfill to the original ground level is less than the minimum required by the specifications for the type of pipe involved until the minimum cover has been provided.

3.3.4. **Cement Stabilized Backfill.** Backfill the excavation to the elevations shown with cement-stabilized backfill when shown on the plans. Use cement-stabilized backfill that contains aggregate conforming to the gradation limits shown in Table 1, water, and a minimum of 7% hydraulic cement based on the dry weight of the aggregate, in accordance with Tex-120-E.

Place cement-stabilized backfill equally along the sides of structures to prevent strain on or displacement of the structure. Fill voids when placing cement-stabilized backfill. Use hand-operated tampers if necessary to fill voids.

3.3.5. **Flowable Backfill**. Backfill the excavation with flowable backfill to the elevations indicated when shown on the plans. Prevent the structure from being displaced during the placement of the flowable fill, and prevent flowable fill from entering manholes/inlets and culverts, and drainage structures.

## 4. MEASUREMENT

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.

4.1. **Structural Excavation**. Unless shown on the plans as a pay item, structural excavation quantities shown are for information purposes only.

When structural excavation is specified as a pay item, structural excavation for pipe headwalls, inlets, manholes, culvert or storm drain extensions less than 15 ft. long, bridge abutments, retaining walls, and side road and private entrance pipe culverts will not be measured. No allowance will be made for variance from plans quantity incurred by an alternate bid.

When specified as a pay item, structural excavation will be measured by the cubic yard as computed by the average end areas method. Excavation diagrams on the plans take precedence over the provisions of this Article.

4.1.1. **Boundaries of Measurement**.

4.1.1.1. **Pipe**.

4.1.1.1.1. **Pipe up to 42 Inches**. For pipe up to 42 in. nominal or equivalent diameter, no material outside of vertical planes 1 ft. beyond and parallel to the horizontal projection of the outside surfaces of the pipe will be included.

4.1.1.1.2. **Pipe Larger than 42 Inches**. For pipes larger than 42 in. nominal or equivalent diameter, no material outside of vertical planes located 2 ft. beyond and parallel to the horizontal projection of the outside surfaces of the pipe will be included.

Quantities for excavation in fill above natural ground include 1 ft. above the top of the pipe regardless of the height of completed fill. Excavation for pipe will be measured between the extreme ends of the completed structure including end appurtenances as shown on the plans and from centerline to centerline of inlets, manholes, etc.

4.1.1.2. **Structural Plate Structures**. No material outside of vertical planes 3 ft. beyond and parallel to the horizontal projection of the outside surfaces of the structure will be included. When the quality of the existing soil or embankment is less than that of the proposed backfill material, the limits of measurement will be extended to vertical planes located 1/2 of the span beyond the horizontal projection of the outside surfaces of the structure.

4.1.1.3. **Footings, Walls, Boxes, and Other Excavation**. No material outside of vertical planes 1 ft. beyond and parallel to the edges of the footings or outside walls will be included whether or not a cofferdam or shoring is used. When plans provide the option of cast-in-place or precast boxes, measurement will be based on the cast-in-place option.

Where excavation in addition to that allowed for the footings is required for other portions of the structure, measurement for the additional excavation will be limited laterally by vertical planes 1 ft. beyond the face of the member and parallel to it, and vertically to a depth of 1 ft. below the bottom of the member.

4.1.1.4. Excavation near Roadways and Channels. At structure sites other than culverts and pipe excavations, the measurement of structural excavation will include only material below or outside the limits of the completed road or channel excavation. Roadway and channel excavation will be paid under Item 110, "Excavation." For culverts except side road and private entrance culverts, excavation within the limits of the structure and below or outside the limits of the completed roadway excavation will be measured as structural excavation.

4.1.2. Falsework. No measurement will be made for excavation necessary for placing forms or falsework that exceeds the limits given in Section 400.4.1.1., "Boundaries of Measurement."

4.1.3. Swelling. Measurement will not include materials removed below footing grades to compensate for anticipated swelling due to pile-driving, nor will it include material required to be removed due to swelling beyond the specified limits during pile-driving operations.

4.1.4. Cave-Ins. Measurement will not include additional volume caused by slips, slides, cave-ins, silting, or fill material resulting from the action of the elements or the Contractor's operation.

4.1.5. Undercut. Where rock or other incompressible or unstable material is undercut to provide a suitable foundation for pipe or box sections, such material below grade directed to be removed will be measured for payment.

4.1.6. Grade Change. Additional measurement will be made of the volume of excavation involved in the lowering or raising of the elevation of a footing, foundation, or structure unit, when such grade change is authorized.

4.2. Cement-Stabilized Backfill. Cement-stabilized backfill will be measured by the cubic yard as shown on the plans.

4.3. Cutting and Restoring Pavement. Cutting and restoring pavement will be measured by the square yard as shown on the plans. Excavation below pavement or base will be measured as structural excavation of the pertinent type.

## 5. PAYMENT

5.1. Structural Excavation. Unless specified as a pay item, structural excavation and backfill performed, and material furnished in accordance with this Item will not be paid for directly but are subsidiary to pertinent Items.

When structural excavation is specified as a pay item, the excavation and backfill work performed, and materials furnished will be paid for at the unit price bid for "Structural Excavation," "Structural Excavation (Box)," "Structural Excavation (Pipe)," and "Structural Excavation (Bridge)." This price includes concrete to compensate for excavation that has extended below grade for bridge foundations and retaining walls, and backfilling and compacting areas that were removed as part of structural excavation.

Cofferdams or other measures necessary for supporting excavations less than 5 ft. deep will not be measured or paid for directly but will be subsidiary to the Contract.

Foundation seal concrete for cofferdams, when required, will be paid for as provided in the pertinent Items. If no direct method of payment is provided in the Contract, the work will be measured and paid for in accordance with Article 9.7., "Payment for Extra Work and Force Account Method." Seal placed for the convenience of the Contractor will not be paid for.

Unless otherwise provided, stone or lean concrete backfill around structures as provided for in Section 400.3.3.2., "Bridge Foundations, Retaining Walls, Manholes/Inlets, and Box Culverts," will be measured and paid for as extra work in accordance with Article 9.7., "Payment for Extra Work and Force Account Method."

When structural excavation is specified as a pay item, a partial payment of 50% of the bid price will be made for structural excavation completed to the satisfaction of the Engineer but not backfilled. The remaining amount will be paid upon completion of backfilling. When the Contractor elects to excavate beyond plan requirements, no measurement will be made of the additional volume.

5.2. Removal and Replacement of Unsuitable or Incompressible Material. Removal and replacement of material will be paid for if directed. Removal and replacement of material or placement of special material made necessary by the softening of founding material due to the Contractor's sequence of work or operation, will be at the Contractor's expense. Special material used or additional excavation made for the Contractor's convenience will not be paid for.

5.2.1. Structural Excavation as a Pay Item. Where special materials are not required or specified, payment for the removal and replacement of unstable or incompressible material will be made at a price equal to 200% of the unit price bid per cubic yard for Structural Excavation. When the Contractor elects to remove and replace material deeper than directed, no measurement will be made on that portion below the directed elevation. This price is full compensation for removing the unstable or incompressible material; furnishing, hauling, placing, and compacting suitable replacement material; and equipment, labor, tools, and incidentals.

When the plans specify or when directed, the use of special materials such as flexible base, cement-stabilized base, cement-stabilized backfill, or other special material, payment for excavation below footing grades will be made at the unit price bid for Structural Excavation. Payment for furnishing, hauling, placing, and compacting the flexible base, cement-stabilized base, cement-stabilized backfill, or other special materials will be made at the unit price bid for these items in the Contract, or, if the required material is not a bid item, in accordance with Article 9.7., "Payment for Extra Work and Force Account Method."

5.2.2. Structural Excavation Not a Pay Item. Where special materials for backfill are not required or specified, payment for the authorized removal and replacement of unstable or incompressible material will be measured and paid for at $15 per cubic yard of material removed. This price is full compensation for removing the unstable or incompressible material; furnishing, hauling, placing, and compacting suitable replacement material; and equipment, labor, tools, and incidentals.

When the plans specify or when directed, the use of special materials such as flexible base, cement-stabilized base, cement-stabilized backfill, or other special material, excavation below the footing grades will be paid for at $10 per cubic yard. Payment for furnishing, hauling, placing, and compacting the flexible base, cement-stabilized base, cement-stabilized backfill, or other special materials will be made at the unit price bid for these items, or, if the required material is not a bid item, in accordance with Article 9.7., "Payment for Extra Work and Force Account Method."

5.3. Lowering of a Structure Foundation. If the Engineer requires a structure foundation to be lowered to an elevation below the grade shown on the plans, overexcavation will be paid in accordance with Table 2.

Table 2
Payment for Required Overexcavation

| Variance of Revised Footing Grade from Plan Grade | Payment Terms | Variance of Revised Footing Grade from Plan Grade |
|---|---|---|
| | "Structural Excavation" is a Bid Item | "Structural Excavation" is not a Bid Item |
| Up to and including 5 ft. | Unit price equal to 115% of unit price bid for "Structural Excavation" | $10 per cubic yard |
| Over 5 ft. up to 10 ft. | Unit price equal to 125% of unit price bid for "Structural Excavation" | $12 per cubic yard |
| Over 10 ft. | In accordance with Article 9.7., "Payment for Extra Work and Force Account Method." | |

5.4. Cement-Stabilized Backfill. Cement-stabilized backfill will be paid for at the unit price bid for "Cement-Stabilized Backfill."

5.5. Cutting and Restoring Pavement. Cutting and restoring pavement will be paid for at the unit price bid for "Cutting and Restoring Pavement" of the type specified.

Work done to repair damage to base or pavement incurred outside the limits shown on the plans, or the limits authorized, will not be measured for payment.

The unit prices bid are full compensation for excavation including removing obstructions and plugging drainage systems; bedding and backfilling including placing, sprinkling and compaction of material; soundings; cleaning and filling seams; constructing and removing cofferdams; de-watering, sheeting, or bracing excavations up to and including 5 ft. deep; pumps; drills; explosives; disposition of surplus material; cutting pavement and base to neat lines; and materials, hauling, equipment, labor, tools, and incidentals.
Protection methods for open excavations deeper than 5 ft. will be measured and paid for as required under Item 402, "Trench Excavation Protection.

# Item 402
# Trench Excavation Protection

## 1. DESCRIPTION

Furnish and place excavation protection for trenches 5 ft. or greater in depth.

## 2. CONSTRUCTION

Provide vertical or sloped cuts, benches, shields, support systems, or other systems providing the necessary protection in accordance with OSHA Standards and Interpretations, 29 CFR 1926, Subpart P, “Excavations.”

## 3. MEASUREMENT

This Item will be measured by the foot along the long axis of the trench where the depth of trench exceeds 5 ft. This measurement includes all required trench protection, including trench ends.

## 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 “Trench Excavation Protection.” This price is full compensation for excavation and backfill required for excavation protection; furnishing, placing, and removing shoring, sheeting, or bracing; de-watering or diversion of water; jacking and jack removal; and equipment, labor, materials, tools, and incidentals.

# Item 404
# Driving Piling

## 1. DESCRIPTION

Drive piling.

## 2. EQUIPMENT

2.1. **Driving Equipment.** Use power hammers for driving piling with specified bearing resistance. Use power hammers that comply with Table 1. Gravity hammers may be used for driving sheet piling and timber piling if no required design load is shown on the plans.

For initial rating of diesel hammers to determine compliance with the requirements of Table 1, the height of fall of the ram of the single-acting (open-end) hammer must be 7 ft. For a double-acting (enclosed ram) hammer, the energy rating must be 85% of the rated output by the manufacturer.

A hammer that produces less energy than required by Table 1 may be approved if a wave equation analysis indicates the hammer can drive the specified pile against a bearing resistance of 3 times the required design load before reaching 0.1 in. of penetration per blow. The bearing resistance of the piling driven with this particular equipment will be determined in accordance with the Wave Equation Method.

Use an air compressor that supplies the volume and pressure specified by the manufacturer of the hammer. Provide an accurate pressure gauge.

Maintain the valve mechanism and other parts of power hammers so the hammer will operate at the speed and stroke length specified by the manufacturer.

Equip enclosed ram diesel hammers with a gauge and provide charts to evaluate the equivalent energy being produced. Calibrate the gauge before work begins, whenever gauge accuracy is in question, and at least once each 6 months.

Table 1
Size of Driving Equipment

| Piling Type | Hammer Type | Ram Weight (lb.) | Maximum Ram Stroke (ft.) | Minimum Hammer Energy (ft.-lb.)[1] |
|---|---|---|---|---|
| Timber | Air, Hydraulic | 2,000 Min | 5 | 330R |
| | Diesel | 2,000 Min | 10 | 330R |
| Steel | Air, Hydraulic | 3,000 Min | 5 | Larger of 250R or 2-1/2 Wp |
| | Diesel | 2,000 Min | 10 | Larger of 250R or 2-1/2 Wp |
| Concrete | Air, Hydraulic | 3,000 Min, but not less than 1/4 Wp | 5 | 250R, but not less than 1 ft.-lb. per pound of pile weight |
| | Diesel | 2,700 Min, but not less than 1/4 Wp | 8[2] | 250R, but not less than 1 ft.-lb. per pound of pile weight |

1. R = Design load in tons. Wp = Weight of pile in pounds based on plan length.
2. Diesel hammers with less ram weight or greater ram stroke are permitted if a wave equation analysis indicates the combination of ram weight, stroke, and cushioning will not overstress the piling.

Provide hammer cushion consisting of layers of micarta and aluminum or other material specifically produced and approved for this application. Use a wood, wire rope, or asbestos hammer cushion only if permitted.

Regulate the height of fall when using gravity hammers to avoid damage to the piling.

Drive all test piling in a structure or in any approved segment of it with the same hammer, and use the same type and size hammer to drive the remainder of the piling in the structure or segment.

Equip pile drivers with leads constructed to allow freedom of movement of the hammer and to provide adequate support to the pile during driving. The longitudinal axis of the leads, hammer, and pile should coincide.

Ensure leads are long enough, except where piling is driven through water, that a follower will not be necessary. Use 1 pile in each 10 that is long enough to permit driving without a follower when driving piling underwater and a follower is required. Drive it as a test pile for proper correlation of the follower-driven piling. Payment will be made as regular piling.

Hammers designed to operate underwater may be used for underwater driving without a follower and without the correlation required for other hammers.

2.2. Protection of Pile Heads. Use a steel driving head (helmet) suitable for the type and size of piling. Drive steel H-piling and sheet piling with a helmet compatible with the specific pile shape driven.

Provide a cushion block for concrete piling between the driving head and the top of the pile. Use a cushion block that is a minimum of 4 in. thick for short piling (50 ft. or less) and at least 6 in. thick for longer piling unless otherwise directed. Use multiple layers of one of the following:

- 3/4-in. or 1-in. structural grade southern pine or fir plywood;
- green oak or gum, with the grain of the wood horizontal; or
- other approved material specifically produced for this application.

Pay special attention to the condition of the cushioning material. Drive no more than 3 piles with one cushion block. Change cushioning more frequently if necessary to prevent damage. Immediately replace any cushion block that has ignited. Do not use a tight-fitting driving helmet for concrete piling. Allow room for slight movement, but ensure the driving helmet is not large enough for the pile head to rotate freely. Center concrete piling and cushion within the helmet throughout the driving operation.

## 3. CONSTRUCTION

This Item uses the following terms:

- Foundation Piling. Piling placed under interior bent footings or retaining wall abutment footings.
- Trestle Piling. Piling embedded directly into the abutment cap or interior bent cap.
- Sheet Piling. Retaining piling not considered either foundation or trestle piling.
- Test Piling. Specific piling driven to investigate site conditions and determine regular piling lengths.
- Test-Loaded Piling. Specific piling driven and test-loaded to investigate site conditions and determine regular piling lengths. Do not fabricate regular piling until test loading and analysis is completed.
- Regular Piling. All piling other than test piling and test-loaded piling.

Do not fabricate regular piling until test pile-driving and analysis or test loading and analysis is completed.

Complete the embankment at bridge ends before driving abutment piling. Refer to Item 423, “Retaining Walls,” for provisions on piling that passes through the structural volume of retaining walls.

Do not drive foundation piling until the footing excavation is complete. Drive concrete piling once the piling concrete, including build-ups, has aged at least 14 days. Do not drive piling in a saltwater environment until the piling concrete, including build-ups, has aged at least 21 days after concrete placement.

Re-drive any piling that is raised when driving adjacent piling. Withdraw and replace any broken, split, or displaced piling, or correct it as directed after a design analysis.

To control excessive stresses resulting in damage to the piling during driving, the following, alone or in combination, may be required:

- increase in cushion thickness,
- reduction of ram stroke,
- heavier ram with a shorter stroke,
- use of pilot holes or jetting when driving through hard or alternating hard and soft strata.

3.1. Tolerance for Driving. Drive piling to the required vertical or batter alignment, within the tolerances of this Section. Drive piling in pilot holes or with templates when necessary to comply with tolerances. Cut off piling reasonably square at the elevation shown on the plans, with a tolerance of no more than 2 in. above or below established cutoff grade. Submit for approval a structural analysis and proposed corrective action, signed and sealed by a licensed professional engineer when tolerances are exceeded and the Engineer requires corrective action.

3.1.1. Trestle Piling.

- Transverse to the centerline of the bent, the top of the piling may be no more than 2 in. from the position shown on the plans.
- Parallel to the centerline of the bent, the top of the piling may be no more than 4 in. from the position shown on the plans.

3.1.2. Foundation Piling.

- The top of each pile may be no more than 4 in. in any direction from the position shown on the plans.
- The center of gravity of the piling group may be no more than 3 in. from the center of gravity determined from plan location.
- The minimum edge distance for piling in a footing is 5 in. Additional concrete required to obtain this edge distance and specified reinforcing steel cover will be at the Contractor's expense.

3.2. Penetration. Piling lengths shown on the plans are the lengths estimated to give required bearing and for estimating purposes only. Drive piling to plan tip elevations or to greater depths as necessary to obtain the required bearing resistance shown on the plans.

The Engineer will establish regular pile lengths on the basis of the test data when test piling or test-loaded piling is used. Drive regular piling to this approximate elevation in these cases and to greater depths as required to obtain the plan bearing resistance.

Provide either pilot holes, jetting, or a combination of both for unusually hard driving conditions, typically less than 0.1 in. of penetration per blow if plan penetration is not obtained. Reduce penetration upon approval when the piling is advanced to within 5 ft. of plan length unless other penetration requirements or bearing evaluation methods govern.

3.3. Pilot Holes. Extend pilot holes no more than 5 ft. below the bottom of footings for foundation piling or 10 ft. below finished ground line for trestle piling, unless the specified penetration cannot be obtained by using the depth of holes indicated or specified. Determine the size and depth of pilot holes from the results of trial operations on the first piling driven or from available test pile data when deeper ones are required. Obtain approval for any excess depth or size of pilot holes. The maximum hole diameter permitted will be approximately 4 in. less than the diagonal of square piling or steel H-piling and 1 in. less than the diameter of round piling. The Engineer may vary hole size and depth to obtain penetration and bearing resistance.

Extend pilot holes through all embankments to natural ground when driving concrete piling.

Where a pilot hole is required in granular material that cannot be sealed off by ordinary drilling methods, a casing may be required around the boring device deep enough to prevent loose material from falling into the pilot hole.

Drive the piling below the depth of the pilot hole a minimum of 1 ft. or 100 blows, but not less than the required bearing resistance shown on the plans. Do not drive piling beyond the point where the penetration per blow is less than 0.1 in. as determined by an average of 10 blows unless directed otherwise. Stop driving if damage to the pile is apparent.

3.4. **Jetting**. Jetting is permitted when the specified penetration cannot be obtained by driving and pilot holes or other methods are not feasible. Submit details of the proposed methods for approval before jetting. The Engineer may authorize varying depths of jetting to achieve the desired results.

Jet as required in conjunction with driving but only to the approved depth. Use enough power for jetting operations to simultaneously operate at least two 2-1/2 in. diameter pipes equipped with 3/4-in. nozzles at a pressure of 150 psi. Perform the jetting with 1 or 2 jets as determined and approved from results of trial operations.

Drive the piling below the depth of the jetting a minimum of 1 ft. or 100 blows, but not less than the required bearing resistance shown on the plans. Do not drive piling beyond the point where the penetration per blow is less than 0.1 in. as determined by an average of 10 blows unless directed otherwise. Stop driving if damage to the pile is apparent.

3.5. **Hammer Formula Method of Bearing Evaluation**. Determine the allowable dynamic bearing resistance of piling by one of the hammer formulas in this Section unless otherwise shown on the plans. If the Engineer has determined a K factor based on test piling, test-loaded piling, or other methods, the computed allowable resistance will be the driving resistance determined based on the appropriate formula multiplied by the K factor. The computed allowable resistance should be greater than or equal to the foundation load shown on the plans.

3.5.1. **Single-Acting Power Hammers**. Use the following formula:

$$P_a = \frac{2WH}{S + 0.1}$$

where:
$P_a$ = allowable dynamic resistance in pounds
$W$ = weight of ram in pounds
$H$ = height of fall of ram in feet (field measured)
$S$ = average penetration in inches per blow for the last 20 blows

Determine $H$ by an approved electronic stroke indicator and blow count logging device provided by the Contractor. Pending approval, H can be determined by visual observation of the ram against a calibrated rod mounted on the hammer or by the following formula:

$$H = 16.1 \times \left| \frac{30}{\left( B \right)} \right|^2 - 0.3$$

where $B$ = blows per minute

3.5.2. **Double-Acting Power Hammers**. Use the following formula:

$$P_a = \frac{2E}{S + 0.1}$$

where:
$P_a$ = allowable dynamic resistance in pounds
E = manufacturer's rated energy in foot-pounds (for double-acting power hammers), or the equivalent energy in foot-pounds determined by a calibrated gauge attached to the hammer and taken when the average

penetration in inches per blow is determined (for enclosed ram diesel hammer)
*S* = average penetration in inches per blow for the last 20 blows

3.5.3. Other Hammer Types. Provide a wave equation analysis for each pile, hammer, soil, and load combination for which the driving system is to be used. The analysis will determine the bearing capacity of the piling.

3.6. Wave Equation Method of Bearing Evaluation. Submit the following data when plans specify the bearing capacity of the piling be determined by the wave equation method:

- manufacturer's specification data for the hammer proposed for use, including all modifications and
- complete description and dimensions of all cushioning material used between the pile and helmet and in the cap block, including total thickness of each, and the direction of grain if wood is used.

These data are used by the Engineer to determine the required number of blows per unit of penetration the hammer must deliver to obtain the required bearing resistance.

After evaluation by the wave equation method, any change in the driving equipment may require re-evaluation. Such changes must be approved before further driving.

3.7. Test Piling. Drive test piling at locations shown on the plans or as directed. Make test piling part of the completed work, cut off or built up to grade as necessary. Use the required bearing evaluation method to determine bearing resistance.

Initially drive test piling to 3 ft. above plan tip elevation of the regular piling for the structure with the blow count recorded for each foot of driving (for example, drive test piling to 13 ft. above its plan tip elevation if the test piling is 10 ft. longer than regular piling). Retain the cushion if used.

Re-drive the test piling the additional length required by the plans at least 7 days after the original driving with the same hammer and cushion originally used. Record the blow count for each inch of driving for the first foot, for every 3 in. for the next 2 ft., and for each foot thereafter.

Provide the data to the Engineer for use in determining regular piling lengths and K factors. The K factor will be determined based on the following formula:

$$K = P_R \blacksquare P$$

where:
*K* = a static correction factor applied to the evaluation method
$P_R$ = re-drive bearing (tons) of the test pile determined by the evaluation method
*P* = original bearing (tons) of test pile determined by the evaluation method

3.8. Test-Loaded Piling.

Provide the data to the Engineer for use in determining regular piling lengths and K factors. The K factor will be determined based on the following formula:

$$K = L \blacksquare P$$

where:
*K* = a static correction factor applied to the evaluation method
*L* = maximum safe static load proven by test load
*P* = bearing resistance of the test-loaded pile determined by the evaluation method

## 4. MEASUREMENT AND PAYMENT

The work performed, materials furnished, equipment, labor, tools, and incidentals will not be paid for directly but will be considered subsidiary to pertinent Items.

# Item 416
# Drilled Shaft Foundations

## 1. DESCRIPTION

Construct foundations consisting of reinforced or non-reinforced concrete drilled shafts.

## 2. MATERIALS

Use materials that meet the requirements of the following Items.

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

Use concrete for drilled shafts that meets the requirements of Table 1 unless otherwise shown on the plans.

Table 1
Concrete for Drilled Shafts

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

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

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

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

Table 2
Slump Requirements

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

Perform a slump loss test in accordance with Tex-430-A before beginning work when casing is to be pulled or concrete is to be placed underwater or under slurry. Provide concrete that will maintain a slump of at least 4 in. throughout the entire anticipated time of concrete placement. Time of concrete placement is described in Section 416.3.6., "Concrete," and Section 416.3.7., "Additional Requirements for Slurry Displacement or Underwater Concrete Placement Methods." Note the temperature of the concrete mix at the beginning of the slump loss test. Place the concrete if its temperature at the time of placement into the drilled shaft is no more than 10°F higher than the slump loss test temperature. Use ice or other concrete cooling ingredients to lower concrete temperature, or run additional slump loss tests at the higher temperatures. Slump loss testing will be waived if anticipated time of concrete placement is less than 90 minutes.

Use mineral drilling slurry that meets the requirements of Table 3, as determined by Tex-130-E. Determine pH of slurry by Tex-128-E or pH paper strips.

Table 3
Mineral Slurry Requirements

| Before Introduction into the Excavation | | | Sampled from the Bottom of the Excavation before Concreting | | |
|---|---|---|---|---|---|
| Specific Gravity | Sand Content | pH | Specific Gravity | Viscosity (sec.) | Sand Content |
| ≤ 1.10 | ≤ 1% | 8–11 | ≤ 1.15 | ≤ 45 | ≤ 4% |

Use mineral slurry consisting of processed bentonite or attapulgite clays mixed with clean fresh water. Do not use partially hydrolyzed polyacrylamide (PHPA) polymeric slurry or any blended mineral-polymer slurry.

If approved, water may be used as the drilling fluid. In this case, all of the provisions of Table 3 must be met except that the maximum specific gravity is not to exceed 1.12.

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

## 3. CONSTRUCTION

Submit Drilled Shaft installation plan for review no later than one month before drilled shaft construction. Include the following in the plan:

- Name and experience record of the drilled shaft superintendent who will be in charge of drilled shaft opertations for this project.
- List of proposed equipment to be used, including cranes, drills, augers, bailing buckets, final cleaning equipment, desanding equipment, slurry pumps, core sampling equipment, tremies or concrete pumps, casing, etc.
- Details of overall construction operation sequence and the sequence of shaft construction in bents or groups.
- Details of shaft excavation methods.
- When the use of slurry is anticipated, details of the slurry mix design and its suitability for the subsurface conditions at the construction site, mixing and storage methods, maintenance methods and disposal procedures.
- Details of methods to clean the shaft excavation.
- Details of reinforcement placement, including support and centralization methods.
- Details of concrete placement, including proposed operational procedures for free fall, tremie or pumping methods.
- Details of casing installation and removal methods.

The installation plan will be reviewed for conformance with the plans, specifications and special provisions. The Contractor will be notified within 14 days of receipt of the installation plan of any additional information required and/or changes necessary to meet the contract requirements. All procedural approvals given will be subject to trial in the field and will not relieve the Contractor of the responsibility to satisfactorily complete the work as detailed in the plans and specifications.

Place the shaft to within the following tolerances:

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

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

3.1. Excavation. The plans indicate the expected depths and elevations for encountering satisfactory bearing material. Excavate as required for the shafts through all materials encountered to the dimensions and elevations shown on the plans or required by the site conditions. Removal of man-made obstructions not shown on the plans will be paid for in accordance with Article 9.7., "Payment for Extra Work and Force Account Method." Adjust the bottom of the shaft or alter the foundation if satisfactory founding material is not encountered at plan elevation, as approved to satisfactorily comply with design requirements. Blasting is not allowed for excavations.

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

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

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

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

3.2. Core Holes. Take cores to determine the character of the supporting materials if directed. Use a method that will result in recovery of an intact sample adequate for judging the character of the founding material. Such cores should be at least 5 ft. deeper than the proposed founding grade or a depth equal to the diameter of the shaft, whichever is greater. Take these cores when the excavation is complete.

3.3. Casing. Use casing when necessary to prevent caving of the material, to exclude ground water, when slurry is used for hole stabilization, or when required as part of the Contractor's Safety Plan. Provide casing with an outside diameter not less than the specified diameter of the shaft. The portion of shaft below the casing may be as much as 2 in. smaller than the specified shaft diameter. No extra compensation will be made for concrete required to fill an oversized casing or oversized excavation. Use casing strong enough to withstand handling stresses and pressures of concrete and of the surrounding earth or water, and that is watertight, smooth, clean, and free of accumulations of hardened concrete.

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

Leave casing in place only if authorized or shown on the plans. Extract casing only after placing the concrete to an appropriate level. Maintain sufficient concrete in the casing at all times to counteract soil and water pressure. Rotate or move the casing up or down a few inches if necessary before and during concrete placement to facilitate extraction of the casing.

3.4. Requirements for Slurry Displacement Method. When soil conditions warrant, use the slurry displacement method to construct drilled shafts unless otherwise shown on the plans. Use this method to support the sides of the excavation with processed mineral slurry that is then displaced by concrete to form a continuous concrete shaft.

Install surface casing to a minimum of 10 ft. below existing ground before introducing slurry. Do not use casing other than surface casing. Do not use surface casing longer than 20 ft. without approval. Do not extract the surface casing until after placing the concrete.

Pre-mix slurry in a reservoir with enough capacity to fill the excavation and for recovery of the slurry during concrete placement. Do not mix slurry in the shaft excavation or other hole. Allow adequate time for hydration of the slurry before introduction into the excavation.

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

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

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

Agitate the congealed slurry to liquefaction if the slurry forms a gel before concrete placement, and whenever directed.

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

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

Extend the reinforcing steel cage as follows if the shaft is lengthened beyond plan length unless directed otherwise.

- Extend the cage to the bottom for shafts supporting structures other than bridges.
- Extend the cage to 25 ft. or to the bottom, whichever is shorter, for bridge shafts with plan lengths less than 25 ft.
- Do not extend the cage for bridge shafts with plan lengths at least 25 ft. that are lengthened less than 33% of plan length.
- Extend the cage as directed for bridge shafts with plan lengths at least 25 ft. that are lengthened more than 33% of plan length.

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

Tie spiral reinforcement to the longitudinal bars at a spacing no more than 24 in., or as required for a stable cage. Ensure lateral reinforcement is not welded to longitudinal bars unless otherwise shown on the plans.

Center the reinforcing steel cage in the excavation using approved "roller" type centering devices unless otherwise approved. Use concrete or plastic chairs to keep the reinforcing cage off of the bottom of the hole. Use centering devices starting at 1.5 ft. off from the bottom of the cage and spaced vertically at intervals not exceeding 10 ft. Use a minimum of 3 centering devices per level at a spacing not to exceed 30 in. Flat or crescent-shaped centralizers ("sleds") are not allowed.

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

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

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

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

3.6 **Concrete**. Perform all work in accordance with Item 420, "Concrete Substructures." Provide concrete with maximum placement temperatures as specified in Table 4. Provide thermal analysis to show and temperature recording devices to verify maximum core temperature requirements are met as specified in Section 420.4.7.14., "Mass Placements," as directed.

Table 4
Maximum Concrete Placing Temperature

| Shaft Size | Mix Design Options 1–5 | Mix Design Options 6–8 |
|---|---|---|
| Diameter < 5 ft. | 95°F | 95°F |
| 5 ft.≤ Diameter ≤ 7 ft. | 95°F | 85°F |
| 7 ft. < Diameter | 85°F | 75°F |

Form portions of drilled shaft that project above natural ground.

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

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

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

Maintain a sufficient head of concrete for cased shafts at all times above the bottom of the casing to overcome hydrostatic pressure. Extract casing at a slow, uniform rate with the pull in line with the axis of the shaft. Monitor the concrete level in the casing during extraction. Stop the extraction and add concrete to the casing as required to ensure a completely full hole upon casing removal. The elapsed time from the mixing of the first concrete placed into the cased portion of the shaft until the completion of extraction of the casing must not exceed the time for which the concrete maintains a slump of over 4 in. in accordance with Article 416.2., "Materials." Modify the concrete mix, the construction procedures, or both for subsequent shafts if the elapsed time is exceeded.

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

3.7. **Additional Requirements for Slurry Displacement or Underwater Concrete Placement Methods**. Place concrete on the same day the shaft is excavated and as soon as possible after all excavation is complete and reinforcing steel is placed. Use an air lift or cleanout bucket of the proper size to clean the bottom of the excavation before placing the reinforcing steel cage and concrete. Place concrete through a closed tremie or pump it to the bottom of the excavation. The minimum tremie diameter will be at least 6 times the maximum size of aggregate used in the concrete mix but not less than 10 in. Initially seal the tremie or pump line to positively separate the concrete from the slurry or water. Place concrete continuously from the beginning of placement until the shaft is completed. Keep the tremie full of concrete and well submerged in the previously placed concrete at all times if using a tremie. Raise the tremie as necessary to maintain the free flow of concrete and the stability of any casing used. Keep the discharge tube submerged in the previously placed concrete at all times if using a pump. Place additional concrete to ensure the removal of any contaminated concrete at the top of the shaft. Allow the top portion of concrete to flush completely from the hole at the completion of the pour until there is no evidence of slurry or water contamination. Do not attempt to remove this concrete with shovels, pumps, or other means. Level the top of shaft with hand tools as necessary.

Use a sump or other approved method to channel displaced fluid and concrete away from the shaft excavation. Recover slurry and dispose of it as approved. Do not discharge displaced fluids into or near

streams or other bodies of water. Provide a collar or other means of capturing slurry and the top portion of concrete flushed from the shaft for pours over water.

Remove the tube, reseal it at the bottom, penetrate with the tube into the concrete already placed by at least 5 ft., and recharge it before continuing if concrete placement is interrupted due to withdrawal of the submerged end of the tremie or pump discharge tube before completion. If this condition exists, notify the Engineer and note the elevation and circumstances related to the loss of seal on the drilled shaft log.

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

3.8. Test Load. Load test shafts, if required.

3.9. Trial Shaft. When required on the plans, construct trial shafts to the depth and diameter specified on the plans. Trial shafts include: drilling the hole, placement of the rebar cage (unless otherwise stated), and placement of the concrete. When trial shafts are required, delay start of production shafts until successful completion of trial shafts.

## 4. MEASUREMENT

4.1. Drilled Shaft. Drilled shaft foundations will be measured by the foot to the bottom of the shaft.

4.1.1. Interior Bents and Piers. Shafts will be measured from a point approximately 6 in. below the finished earthwork elevation at the center of each shaft, unless specific elevations or dimensions are indicated on the plans or unless otherwise directed to meet unusual conditions. The bent height shown on the plans is for estimating purposes only and does not control the top-of-shaft measurement.

4.1.2. Abutment Bents and Retaining Walls. Shafts will be measured from the bottom of footing or cap elevation.

4.1.3. Other Non-Bridge Structures. Shafts, including trial shafts, will be measured from the top of the shaft.

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

## 5. PAYMENT

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

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

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

5.1. Drilled Shaft. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Drilled Shaft," "Drilled Shaft (Non-reinforced)," "Drilled Shaft (Sign Mounts)," "Drilled Shaft (High Mast Pole)," "Drilled Shaft (Roadway Illumination Pole)," or "Drilled Shaft (Traffic Signal Pole)" of the specified diameter, subject to the limitations for overruns authorized by the Engineer given in Section 416.5.1.1., "Overrun."

5.1.1. **Overrun.** Payment for individual completed shaft lengths up to and including 5 ft. in excess of the maximum plan length shaft, as defined in Section 416.5.1.2., "Maximum Plan Length Shaft," will be made at the unitprice bid per foot of the specified diameter.

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

Payment for the portion of individual completed shaft length in excess of 15 ft. more than the maximum plan length shaft, as defined in Section 416.5.1.2., "Maximum Plan Length Shaft," will be made at a unit price equal to 125% of the unit price bid per foot of the specified diameter.

5.1.2. **Maximum Plan Length Shaft**. Payment described above is subject to the following provisions for extra depth drilling:

- For bridge structures, the maximum plan length shaft is the maximum length shaft, regardless of diameter, for any drilled shaft on that specific bridge.
- For retaining walls, the maximum plan length shaft is the maximum length shaft, regardless of diameter, for any drilled shaft on that specific retaining wall.
- For overhead sign structures, the maximum plan length shaft is the maximum length shaft, regardless of diameter, for any overhead sign structures included in the Contract.
- For high mast illumination poles, the maximum plan length shaft is the maximum length shaft, regardless of diameter, for any high mast illumination pole included in the Contract.
- For roadway illumination poles, the maximum plan length shaft is the maximum length shaft, regardless of diameter, for any roadway illumination pole included in the Contract.
- For traffic signal poles, the maximum plan length shaft is the maximum length shaft, regardless of diameter, for any traffic signal pole included in the Contract.

5.2. **Core Hole**. Core holes will be paid at $200 each.

# Item 420
# Concrete Substructures

## 1. DESCRIPTION

Construct concrete substructures including footings, columns, caps, abutments, piers, culverts, other bridge substructure elements, and other concrete structures as indicated.

## 2. MATERIALS

2.1. **Concrete**. Provide concrete in accordance with Item 421, "Hydraulic Cement Concrete." Provide the class of concrete for each type of structure or unit as shown on the plans or in pertinent governing specifications.

2.2. **Grout or Mortar**. Provide grout for dowelling anchors or precast connections in accordance with DMS-4675, "Cementitious Grouts and Mortars for Miscellaneous Applications."

2.3. **Latex Curing Materials**. Provide an acrylic-polymer latex admixture (acrylic resin emulsion per DMS-4640, "Chemical Admixtures for Concrete") suitable for producing polymer-modified concrete or mortar. Do not allow latex to freeze.

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

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

- Provide preformed fiber expansion joint material that conforms to the dimensions shown on the plans.
- Provide preformed bituminous fiber material unless otherwise specified.
- Provide asphalt board that conforms to dimensions shown on the plans.
- Provide re-bonded neoprene filler that conforms to the dimensions shown on the plans.

2.6. **Waterstop**. Provide rubber or polyvinyl chloride (PVC) waterstops in accordance with DMS-6160, "Water Stops, Nylon Reinforced Neoprene Sheet, and Elastomeric Pads," unless otherwise shown on the plans.

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 1 side of the mat.

Provide polyethylene sheeting that is at least 4 mils thick and free from visible defects. Provide only clear or opaque white sheeting when the ambient temperature during curing exceeds 90°F or when applicable to control temperature during mass pours.

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

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 has only 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 in accordance with DMS-6100, "Epoxies and Adhesives," unless otherwise specified.

## 3. EQUIPMENT

3.1. Transporting and Placing Equipment. Use appropriate transporting and placing equipment such as buckets, chutes, buggies, belt conveyors, pumps, or other equipment as necessary. Ensure concrete is not transported or conveyed through equipment made of aluminum.

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

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.

3.2. 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.

3.3. 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 to within ±2°F within the range of 32°F to 212°F for mass concrete operations, cold weather placements, and as otherwise specified.

3.4. Artificial Heating Equipment. Use artificial heating equipment as necessary for maintaining the concrete temperatures as specified in Section 420.4.7.11., "Placing Concrete in Cold Weather."

3.5. Spraying Equipment. Use mechanically powered pressure sprayers, either air or airless, with appropriate atomizing nozzles for the application of membrane curing. Use hand-pressurized spray equipment with 2 or 3 fan-spray nozzles if approved. Ensure the spray from each nozzle overlaps the spray from adjacent nozzles by approximately 50%.

3.6. Concrete Testing Equipment. Provide testing equipment for use by the Engineer 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.

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 in Section 420.4.1., "Schedule Restrictions." 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 in Section 420.4.1., "Schedule Restrictions." 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. Construct and open completed structures to traffic with the following limitations unless otherwise shown on the plans:

4.1.1. Setting Forms. Attain at least 2,500 psi compressive strength before erecting forms on concrete footings supported by piling or drilled shafts, or on individual drilled shafts. Erect forms on spread footings and culvert footings after the footing concrete has aged at least 2 curing days as defined in Section 420.4.10., "Curing Concrete." Place concrete only after the forms and reinforcing steel have been inspected by the Engineer.

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

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

4.1.2. Removal of Forms and Falsework. Keep in place weight-supporting forms and falsework for bridge components and culvert slabs until the concrete has attained a compressive strength of 2,500 psi in accordance with Section 420.4.11., "Removal of Forms and Falsework." Keep all forms for mass placements in place for 4 days following concrete placement unless otherwise approved based on the outcome of the heat control plan outlined in Section 420.4.7.14., "Mass Placements."

4.1.3. Placement of Superstructure Members. Erect or place superstructure members or precast substructure members only after the substructure concrete has attained a compressive strength of 3,000 psi.

4.1.4. Opening to Traffic. Direct traffic culverts may be opened to construction traffic when the design strength specified in Section 421.4.1., "Classification of Concrete Mix Design," has been attained if curing is maintained. Obtain approval before opening direct traffic culverts to the traveling public. Open other noncritical structural and nonstructural concrete for service upon the completion of curing unless otherwise specified or directed.

4.1.5. Post-Tensioned Construction. Ensure strength requirements on the plans for structural elements designed to be post-tensioned are met for stressing and staged loading of structural elements.

4.2. Plans for Falsework and Forms. Submit plans for falsework and forms for the following items: vertical forms for piers and single column bents; load supporting forms for caps and tie-beams; form attachments for bridges to be widened; and other items as indicated or directed. Provide design calculations when requested. Show all essential details of proposed forms, falsework, and bracing. Have a licensed professional engineer design, seal, and sign these plans. Department approval is not required, except as noted in Table 1 of Item 5, "Control of the Work," when forms or falsework are located such that public safety can be affected, 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 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.

4.3. Falsework. Design and construct falsework to safely carry the maximum anticipated loads, including wind loads, and to provide the necessary rigidity. Consult AASHTO's *Guide Design Specifications for Bridge Temporary Works* and *Construction Handbook for Bridge Temporary Works* for falsework and shoring information not indicated below. Submit details in accordance with Section 420.4.2., "Plans for Falsework and Forms."

Design job-fabricated falsework 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.

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

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

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

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

Place falsework that cannot be founded on a satisfactory spread footing on piling or drilled shafts with enough bearing capacity to support the superimposed load without settlement. Drive falsework piling to the required resistance determined by the applicable formula in Item 404, "Driving Piling." Design drilled shafts for falsework to carry the superimposed load using both skin friction and point bearing.

Weld in conformance with Item 448, "Structural Field Welding." Securely brace each falsework bent to provide the stiffness required, and securely fasten the bracing to each pile or column it crosses.

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

4.4. Forms. Submit formwork plans in accordance with Section 420.4.2., "Plans for Falsework and Forms."

4.4.1. General. Provide forms of either timber or metal except where otherwise specified or permitted.

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

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

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

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

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

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

Complete all preparatory work before requesting permission to place concrete.

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

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

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

Provide form lining for all formed surfaces except:

- the inside of culvert barrels, inlets, manholes, and box girders;
- surfaces that are subsequently covered by backfill material or are completely enclosed; and
- any surface formed by a single finished board or by plywood.

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

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

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

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

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

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

Place forms with the form panels symmetrical (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.

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

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

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

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

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

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

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

4.6. Placing Reinforcement and Post-Tensioning. Place reinforcement as provided in Item 440, "Reinforcement for Concrete." Do not weld reinforcing steel supports to other reinforcing steel except where shown on the plans.

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

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 when conditions of wind, humidity, and temperature are such that concrete cannot be placed without the potential for weather-related distress.

Adequately illuminate the entire placement site as approved when mixing, placing, and finishing concrete in non-daylight hours.

Furnish adequate shelter to protect the concrete against damage from rainfall or 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.

4.7.1. Placing Temperature. Place concrete according to the following temperature limits for the classes of concrete defined in Section 421.4.1., "Classification of Concrete Mix Designs."

- Place Class C, F, H, K, or SS concrete only when its temperature at time of placement is between 50°F and 95°F. Increase the minimum placement temperature to 60°F if slag cement is used in the concrete.
- Place Class S concrete, used in this Item only as indicated for culvert top slabs, only when its temperature is between 50°F and 85°F. Increase the minimum placement temperature to 60°F if slag cement is used in the concrete.
- Place Class A, B, and D concrete only when its temperature at the time of placement is greater than 50°F.
- Place mass concrete in accordance with Section 420.4.7.14., "Mass Placements," only when its temperature at the time of placement is between 50°F and 75°F.

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

4.7.3. Workability of Concrete. Place concrete with a slump as specified in Section 421.4.2.5., "Slump." Water may be added to the concrete before discharging any concrete from the truck to adjust for low slump provided that the maximum mix design water–cement ratio is not exceeded. Mix concrete in accordance with Section 421.4.6., "Mixing and Delivering Concrete," after introduction of any additional water or chemical admixtures. Do not add water or chemical admixtures after any concrete has been discharged.

4.7.4. Transporting Concrete. 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.

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

Ensure the subgrade or foundation is moist before placing concrete on grade. Lightly sprinkle the subgrade if dry.

4.7.6. Expansion Joints. Construct joints and devices to provide for expansion and contraction in accordance with plan details.

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

Ensure 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 joint.

4.7.7. Construction Joints. A construction joint is the joint formed by placing plastic concrete in direct contact with concrete that has attained its initial set. Monolithic placement means 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. 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 roughen the top surface of a concrete placement terminating at a horizontal construction joint as soon as practical after initial set is attained.

Thoroughly clean the hardened concrete surface of all loose material, laitance, dirt, and foreign matter, and saturate it with water. Remove all free water and moisten the surface before concrete or bonding grout is placed against it. Ensure the surface of the existing concrete is in a saturated surface-dry condition (SSD) just before placing subsequent concrete. Wet the existing concrete by ponding water on the surface for 24 hr. before placing subsequent concrete. Use high-pressure water blasting if ponding is not possible to achieve SSD conditions 15 to 30 min. before placing the concrete. 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 if a bonding agent is required as indicated on the plans. 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.

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

Ensure concrete free-falls no more than 5 ft. except in the case of drilled shafts, thin walls such as in culverts, or as allowed by other Items. Remove any hardened concrete splatter ahead of the plastic concrete.

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

Deposit concrete in the forms in layers of suitable depth but no more than 36 in. deep unless otherwise permitted.

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. Allow no more than 1 hr. to elapse between adjacent or successive placements of concrete when re-vibration of the concrete is shown on the plans except as otherwise allowed by an approved placing procedure. This time limit may be extended by 1/2 hr. if the concrete contains at least the minimum recommended dosage of a Type B or D admixture.

4.7.9. 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 vibrators vertically where possible. 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.

4.7.10. 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. 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 not exceeding 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 hydraulic cement grout for cast-in-place or grouted systems in accordance with DMS-4675, "Cementitious Grouts and Mortars for Miscellaneous Applications." 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.

4.7.11. 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. Remove and replace concrete as directed at the Contractor's expense if it is determined unsatisfactory due to poor conditions.

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 as follows:

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

Use additional covering, insulated forms, or other means and, if necessary, supplement the covering with artificial heating. Avoid applying heat directly to concrete surfaces. Cure as specified in Section 420.4.10., "Curing Concrete," during this period until all requirements for curing have been satisfied.

Have 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.

4.7.12. Placing Concrete in Hot Weather. Keep the concrete at or below the maximum temperature at time of placement as specified in Section 420.4.7.1., "Placing Temperature." Sprinkle and shade aggregate stockpiles or use ice, liquid nitrogen systems, or other approved methods as necessary to control the concrete temperature.

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

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

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

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

4.7.14. Mass Placements. Develop and obtain approval for a heat control plan for monolithic placements designated on the plans as mass concrete to ensure the following during the heat dissipation period:

- the temperature differential between the central core of the placement and the exposed concrete surface does not exceed 35°F and
- the temperature at the central core of the placement does not exceed 160°F.

Use the ConcreteWorks© software available from the Department, or another approved method based on the guidelines in ACI 207, "Mass Concrete," to develop the heat control plan. The Department will make available technical assistance on the use of ConcreteWorks©. Develop the heat control plan using historical temperature ranges for the anticipated time of the mass placement. Re-create the plan if the work schedule shifts by more than one month.

The heat control plan may include a combination of the following elements:

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

Furnish and install 2 pairs of temperature recording devices, maturity meters, or other approved equivalent devices. Install devices to measure the surface temperature no more than 3 in. from the surface. Install devices to measure the core temperature a distance of half the least dimension from the nearest surface near the point of maximum predicted heat. Use these devices to simultaneously measure the temperature of the concrete at the core and the surface. Maintain temperature control methods for 4 days unless otherwise approved based on the submitted heat control plan. Do not use maturity meters to predict strength of mass concrete. Revise the heat control plan as necessary to maintain the temperature limitations shown above.

If the core temperature exceeds 160°F, the mass concrete element will be subject to review and acceptance by the Engineer using forensic analyses to determine its potential reduction in service life or performance. Proceed with subsequent construction on the affected element only when notified regarding acceptance.

Repair any resulting cracking if the temperature differential between the central core of the placement and the nearest concrete surface exceeds 35°F at no expense to the Department and revise the heat control plan as necessary to prevent further occurrences.

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

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

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

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

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

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

Accurately finish the footing slab at the proper time to provide a smooth uniform surface. Finish top slabs that carry direct traffic as specified in Item 422, “Concrete Superstructures.” Give top slabs of fill type culverts a float finish.

4.8. Extending Existing Substructures. Verify pertinent dimensions and elevations of the existing structure before ordering any required materials.

4.8.1. 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. 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.

4.8.2. 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.

4.8.3. 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, when welded splices are permitted. Install any required dowels in accordance with Section 420.4.7.10., “Installation of Dowels and Anchor Bolts.”

4.8.4. Concrete Preparation. Roughen and clean concrete surfaces that are in contact with new construction before placing forms. Prepare these construction joint surfaces in accordance with Section 420.4.7.7., “Construction Joints.”

4.9. Treatment and Finishing of Horizontal Surfaces. Strike off to grade and finish all unformed upper surfaces. Do not use mortar topping for surfaces constructed under this Section.

Float the surface with a suitable float after the concrete has been struck off.

Slope the tops of caps and piers between bearing areas from the center slightly toward the edge, and slope the tops of abutment and transition bent caps from the backwall to the edge, as directed, so water drains from the surface. Give the concrete a smooth trowel finish. Construct bearing areas for steel units in accordance with Section 441.3.11.6., "Bearing and Anchorage Devices." Give the bearing area under the expansion ends of concrete slabs and slab and girder spans a steel-trowel finish to the exact grades required. Give bearing areas under elastomeric bearing pads or nonreinforced bearing seat buildups a textured, wood float finish. Do not allow the bearing area to vary from a level plane more than 1/16 in. in all directions.

Cast bearing seat buildups or pedestals for concrete units integrally with the cap or a construction joint. Provide a latex-based mortar, an epoxy mortar, or an approved proprietary bearing mortar for bearing seat buildups cast with a construction joint. Mix mortars in accordance with the manufacturer's recommendations. Construct pedestals of Class C concrete, reinforced as shown on the plans or as indicated in Figure 1 and Figure 2. The Engineer of Record will design pedestals higher than 12 in.

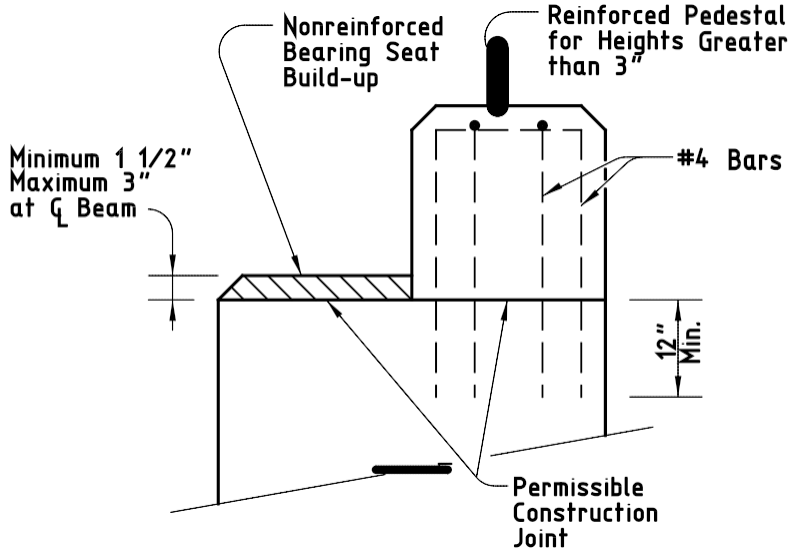


Figure 1
Section through Bearing Seat Buildups

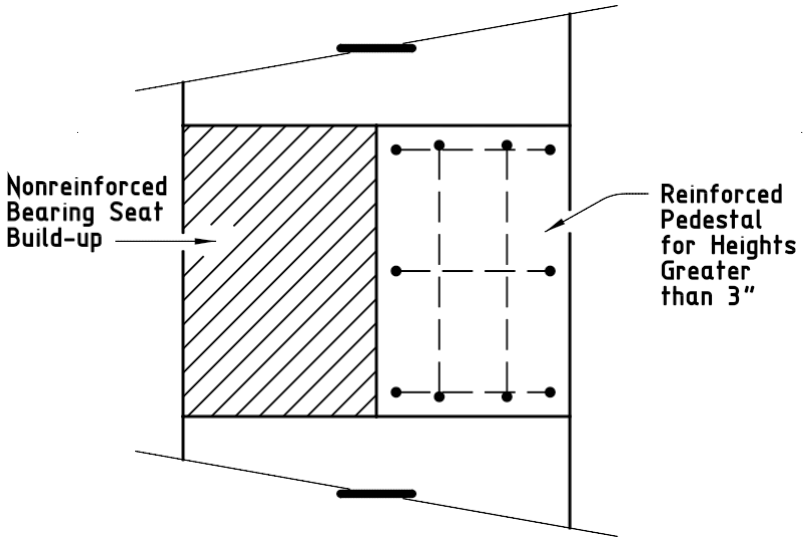


Figure 2
Plan View of Bearing Seat Buildups

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

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

Cure all concrete for 4 consecutive days except as allowed for the curing options listed below. Use form or membrane curing for vertical surfaces unless otherwise approved. Use only water curing for horizontal surfaces of HPC or mass concrete. Use water or membrane curing for horizontal or unformed surfaces for all other concrete.

Use one of the following curing options for vertical surfaces, unless indicated otherwise.

- Form cure for 48 hr. after placement.
- Form cure for 12 hr. after placement followed by membrane curing.
- For HPC Concrete, form cure for 48 hr. after placement followed by membrane curing.
- For mass concrete, form cure as required by the heat control plan followed by membrane curing if forms are removed before 4 days.

Apply membrane curing, if used, within 2 hr. of form removal.

Use only water curing in accordance with this Section for the top surface of any concrete unit upon which concrete is to be placed and bonded at a later interval (stub walls, caps with backwalls, risers, etc.).

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

4.10.1. Form Curing. When forms are left in intimate contact with the concrete, other curing methods are not required except for exposed surfaces and for cold weather protection. Use another approved curing method if forms are removed before the 4-day required curing period.

4.10.2 Water Curing. Keep all exposed surfaces of the concrete wet continuously for the required curing time. Use water curing in accordance with concrete mixing water in Section 421.2.5., "Water." Do not use seawater or water that stains or leaves an unsightly residue.

4.10.2.1. Blankets. Keep the concrete continuously wet by maintaining wet cotton or burlap 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.

4.10.2.2. Water Spray. Overlap sprays or sprinklers to keep all unformed surfaces continuously wet.

4.10.2.3. Ponding. Cover the surfaces with at least 2 in. of clean granular material, kept wet at all times, or at least 1 in. deep water. Use a dam to retain the water or saturated granular material.

4.10.3. Membrane Curing. Choose either Type 1-D or Type 2 membrane-curing compound unless otherwise shown on the plans. Use the same type of curing compound on an individual member.

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

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

4.11. Removal of Forms and Falsework. Remove forms for vertical surfaces after the concrete has aged a minimum of 12 hr. after initial set provided the removal can be done without damage to the concrete unless otherwise directed. Keep forms for mass placements in place for 4 days following concrete placement unless otherwise approved based on the outcome of the heat control plan outlined in Section 420.4.7.14., "Mass Placements."

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

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

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 metal may be removed without undue chipping or spalling of the concrete, and so 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.

4.12. Defective Work. Repair defective work as soon as possible. Remove and replace at the expense of the Contractor any defect that cannot be repaired to the satisfaction of the Engineer.

4.13. Ordinary Surface Finish. Apply an ordinary surface finish to all concrete surfaces. Provide flat or textured surfaces as specified with uniform appearance. Address defects and surface irregularities not consistent with the intent of the expected finish by the following:

- Chip away all loose or broken material to sound concrete where porous, spalled, or honeycombed areas are visible after form removal.
- Repair spalls in accordance with the procedures outlined in the *Concrete Repair Manual* available on the Department's website.
- Clean and fill holes or spalls caused by the removal of form ties, etc., with latex grout, cement grout, or epoxy grout as approved. Fill only the holes. Do not blend the patch with the surrounding concrete. On surfaces to receive a rub finish, chip out exposed parts of metals chairs to a depth of 1/2 in. and repair the surface.
- Remove all fins, rust staining, runs, drips, or mortar from surfaces that will be exposed. Smooth all form marks and chamfer edges by grinding or dry-rubbing.
- Ensure all repairs are dense, well-bonded, and properly cured. Finish exposed large repairs to blend with the surrounding concrete where a higher class of finish is not specified.

Apply an ordinary surface finish as the final finish to the following exposed surfaces unless noted otherwise:

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

Form marks and chamfer edges do not need to be smoothed for the inside of culvert barrels.

## 5. MEASUREMENT

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

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

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

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

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

5.2. Plans Quantity. Structure elements designated in Table 1 and measured by the cubic yard are plans quantity measurement items. The quantity to be paid for plans quantity items is the quantity shown in the proposal unless modified by Article 9.2., "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.

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

Table
Plans Quantity Payment
(Cubic Yard Measurement Only)

| | |
|---|---|
| Culverts and culvert wing walls | Abutments |
| Headwalls for pipe | Footings |
| Retaining walls | Pile bent caps |
| Inlets and manholes | Post-tensioned elements |

Note—Other elements, including pier and bent concrete, may be paid for as "plans quantity" when shown on the plans.

5.3. Measured in Place. Items not paid for as "plans quantity" will be measured in place.

## 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 class of concrete and element identified and by the special designation when appropriate. This price is full compensation for furnishing, hauling, and mixing concrete materials; furnishing, bending, fabricating, splicing, welding and placing the required reinforcement; clips, blocks, metal spacers, ties, wire, or other materials used for fastening reinforcement in place;
furnishing, placing, and stressing post-tensioning system; placing, finishing, and curing concrete; mass placement controls; applying ordinary surface finish; furnishing and placing drains, metal flashing strips, and
expansion-joint material; excavation, subgrade preparation; and forms and falsework, 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.

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

In addition to the work described above, for extending structures the unit prices bid for the various classifications of concrete shown are full compensation for removing and disposing of, if necessary, the designated portion of the existing structure; removing, stockpiling if necessary, and replacing headwall units for reuse; cleaning, bending, and cutting of exposed reinforcing steel; splicing of new reinforcing steel to existing reinforcing steel; installation of dowels; and cleaning and preparing existing concrete surfaces.

# Item 421
# Hydraulic Cement Concrete

## 1. DESCRIPTION

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

## 2. MATERIALS

Use materials from prequalified sources listed on the Department website. Provide coarse and fine aggregates from sources listed in the Department's *Concrete Rated Source Quality Catalog* (CRSQC). Use materials from non-listed sources only when tested and approved by the Engineer before use. Allow 30 calendar days for the Engineer to sample, test, and report results for non-listed sources. Do not combine approved material with unapproved material.

2.1. Cement. Furnish cement conforming to DMS-4600, "Hydraulic Cement."

2.2. Supplementary Cementing Materials (SCM).

- Fly Ash. Furnish fly ash, ultra-fine fly ash (UFFA), and modified Class F fly ash (MFFA) conforming to DMS-4610, "Fly Ash."
- Slag Cement. Furnish Slag Cement conforming to DMS-4620, "Ground Granulated Blast Furnace Slag."
- Silica Fume. Furnish silica fume conforming to DMS-4630, "Silica Fume."
- Metakaolin. Furnish metakaolin conforming to DMS-4635, "Metakaolin."

2.3. Cementitious Material. Cementitious materials are the cement and supplementary cementing materials used in concrete.

2.4. Chemical Admixtures. Furnish admixtures conforming to DMS-4640, "Chemical Admixtures for Concrete."

2.5. Water. Furnish mixing and curing water that is free from oils, acids, organic matter, or other deleterious substances. Water from municipal supplies approved by the Texas Department of Health will not require testing. Provide test reports showing compliance with Table 1 before use when using water from other sources.

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

Table 1
Chemical Limits for Mix Water

| Contaminant | Test Method | Maximum Concentration (ppm or mg\L) |
|---|---|---|
| Chloride (Cl) | ASTM C114 | |
| Prestressed concrete | | 500 |
| Bridge decks & superstructure | | 500 |
| All other concrete | | 1,000 |
| Sulfate (SO4) | ASTM C114 | 2,000 |
| Alkalies (Na2O + 0.658K2O) | ASTM C114 | 600 |
| Total solids | ASTM C1603 | 50,000 |

Table 2
Acceptance Criteria for Questionable Water Supplies

| Property | Test Method | Limits |
|---|---|---|
| Compressive strength, min % control at 7 days | ASTM C31, ASTM C39[1,2] | 90 |
| Time of set, deviation from control, h:min. | ASTM C403 | From 1:00 early to 1:30 later |

1. Base comparisons on fixed proportions and the same volume of test water compared to the control mix using 100% potable water or distilled water.
2. Base comparisons on sets consisting of at least 2 standard specimens made from a composite sample.

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

2.6. Aggregate.

2.6.1. Coarse Aggregate. Provide coarse aggregate consisting of durable particles of gravel, crushed blast furnace slag, recycled crushed hydraulic cement concrete, crushed stone, or combinations which are free from frozen material and from injurious amounts of salt, alkali, vegetable matter, or other objectionable material, either free or as an adherent coating. Provide coarse aggregate of uniform quality throughout.

Provide coarse aggregate with the requirements listed in Table 3 unless otherwise shown on the plan.

Table 3
Coarse Aggregate Requirements

| Description | Test Method | Limit |
|---|---|---|
| Weight of Clay Lumps, % Max | Tex-413-A | 0.25 |
| Weight of Shale, % Max | | 1.0 |
| Weight of Laminate and Friable Particle, % Max | | 5.0 |
| L.A. Abrasion Wear, % Max | Tex-410-A | 40 |
| 5-Cycle Magnesium Sulfate Soundness,[1,2] non-air-entrained concrete, % Max | Tex-411-A | 25 |
| 5-Cycle Magnesium Sulfate Soundness,[1,3] air-entrained concrete, % Max | | 18 |
| Loss by Decantation, % Max | Tex-406-A | 1.5 |

1. Recycled crushed hydraulic cement concrete is not subject to 5-cycle magnesium sulfate soundness requirements.
2. Allowed when air-entrained concrete is used at the Contractor's option.
3. Only when air-entrained concrete is required by the plans.

Increase the loss by decantation limit to 3.0% for all classes of concrete and 5.0% for Class A, B, and P if the material finer than the No. 200 sieve is determined to be at least 85% calcium carbonate in accordance with Tex-406-A, Part III, in the case of coarse aggregates made primarily from crushing stone unless otherwise shown on the plans. Provide test results upon request.

Provide coarse aggregate conforming to the gradation requirements shown in Table 4 when tested in accordance with Tex-401-A unless otherwise specified.

Table 4
Coarse Aggregate Gradation Chart

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

1. Corresponding ASTM C33 gradation shown in parentheses.

2.6.2. Fine Aggregate. Provide fine aggregate consisting of clean, hard, durable particles of natural, manufactured sand, recycled crushed hydraulic cement concrete, slag, lightweight aggregate, or a combination thereof. Provide fine aggregate free from frozen material and from injurious amounts of salt, alkali, vegetable matter, or other objectionable material.

Provide fine aggregates with the requirements in Table 5 unless otherwise shown on the plans.

Table 5
Fine Aggregate Requirements

| Description | Test Method | Limit |
|---|---|---|
| Weight of Clay Lumps, % Max | Tex-413-A | 0.50 |
| Organic Impurities[1] | Tex-408-A | Color not darker than standard |
| Sand Equivalent | Tex-203-F | 80 |
| Fineness Modulus | Tex-402-A | 2.3 to 3.1 |

1. Only when air-entrained concrete is specified.

Provide fine aggregate or combinations of aggregates conforming to the gradation requirements shown in Table 6 when tested in accordance with Tex-401-A unless otherwise specified.

Table 6
Fine Aggregate Gradation Chart (Grade 1)

| Sieve Size | Percent Passing |
|---|---|
| 3/8" | 100 |
| #4 | 95–100 |
| #8 | 80–100 |
| #16 | 50–85 |
| #30 | 25–65 |
| #50 | 10–35[1] |
| #100 | 0–10 |
| #200 | 0–3[2] |

1. 6–35 when sand equivalent value is greater than 85.
2. 0–6 for manufactured sand.

2.6.3. Intermediate Aggregate. Provide intermediate aggregate consisting of clean, hard, durable particles of natural, manufactured sand, slag, recycled crushed hydraulic cement concrete, lightweight aggregate, or a combination thereof when optimized aggregate gradation (OAG) concrete is specified or when used at the Contractor's option. Provide intermediate aggregate free from frozen material and injurious amounts of salt, alkali, vegetable matter, or other objectionable material.

Provide intermediate aggregate with the requirements in Table 7.

Table 7
Intermediate Aggregate Requirements

| Description | Test Method | Limit |
|---|---|---|
| Weight of Clay Lumps, % Max | Tex-413-A | 0.50 |
| L.A. Abrasion Wear,[1] % Max | Tex-410-A | 40 |
| 5-Cycle Magnesium Sulfate Soundness,[1,2,3] non-air-entrained concrete, % Max | Tex-411-A | 25 |
| 5-Cycle Magnesium Sulfate Soundness,[1,2,4] air-entrained concrete, % Max | | 18 |
| Organic Impurities[5] | Tex-408-A | Color not darker than standard |
| Loss by Decantation,[1] % Max | Tex-406-A | 1.5 |

1. Only applies to the portion retained on the No. 4 sieve, if more than 30% of the intermediate aggregate is retained on the No. 4 sieve.
2. Recycled crushed hydraulic cement concrete is not subject to 5-cycle magnesium sulfate soundness requirements.
3. Allowed when air-entrained concrete is used at the Contractor's option.
4. Only when air-entrained concrete is required by the plans.
5. Only applies to the portion passing the 3/8 in. sieve, if more than 30% of the intermediate aggregate is passing the 3/8 in. sieve.

For the portion retained on the No. 4 sieve, if more than 30% of the intermediate aggregate is retained on the No. 4 sieve, and in the case of aggregates made primarily from crushing stone, unless otherwise shown on the plans, the loss by decantation may be increased to 3.0% for all classes of concrete and 5.0% for Class A, B, and P if the material finer than the No. 200 sieve is determined to be at least 85% calcium carbonate in accordance with Tex-406-A, Part III. Provide test results upon request.

2.7. Mortar and Grout. Furnish pre-packaged grouts conforming to DMS-4675, "Cementitious Grouts and Mortars for Miscellaneous Applications," when specified for applications other than post-tension grouting.

Section 421.4.2.6., "Mix Design Options," does not apply for mortar and grout.

2.8. Storage of Materials.

2.8.1. Cement and Supplementary Cementing Materials. Store all cement and supplementary cementing materials in weatherproof enclosures that will protect them from dampness or absorption of moisture.

When permitted, small quantities of packaged cementitious material may be stored in the open, on a raised platform, and under waterproof covering for up to 48 hr.

2.8.2. Aggregates. Handle and store concrete aggregates in a manner that prevents contamination with foreign materials. Clear and level the sites for the stockpiles of all vegetation if the aggregates are stored on the ground and do not use the bottom 6-in. layer of aggregate without cleaning the aggregate before use.

Maintain separate stockpiles and prevent intermixing when conditions require the use of 2 or more grades of coarse aggregates. Separate the stockpiles using physical barriers where space is limited. Store aggregates from different sources in different stockpiles unless the Engineer authorizes pre-blending of the aggregates. Minimize segregation in stockpiles. Remix and test stockpiles when segregation is apparent.

Sprinkle stockpiles to control moisture and temperature as necessary. Maintain reasonably uniform moisture content in aggregate stockpiles.

2.8.3. Chemical Admixtures. Store admixtures in accordance with manufacturer's recommendations and prevent admixtures from freezing.

## 3. EQUIPMENT

3.1. Concrete Plants and Mixing Equipment. Except for volumetric stationary plant or truck (auger) mixers, each plant and truck mixer must be currently certified by the National Ready Mixed Concrete Association (NRMCA) or have an inspection report signed and sealed by a licensed professional engineer showing concrete measuring, mixing, and delivery equipment meets all requirements of ASTM C94. A new certification or signed and sealed report is required every time a plant is moved. Plants with a licensed professional engineer's inspection require re-inspection every 2 yr. Provide a copy of the certification or the

signed and sealed inspection report to the Engineer. Remove equipment or facilities from service until corrected when they fail to meet specification requirements.

When allowed on the plans or by the Engineer, for concrete classes not identified as structural concrete in Table 8 or for Class C concrete not used for bridge-class structures, the Engineer may inspect and approve all plants and trucks instead of the NRMCA or non-Department engineer-sealed certifications. The criteria and frequency of Engineer approval of plants and trucks is the same used for NRMCA certification.

Inspect and furnish inspection reports on the condition of blades and fins and their percent wear from the original manufacturer's design for truck mixers and agitators annually. Repair mixing equipment exhibiting 10% or more wear before use. If an inspection within 12 mo. is not practical, a 2-mo. grace period (for a maximum of 14 mo. between inspections) is permitted.

3.1.1. Scales. Check all scales before beginning of operations, after each move, or whenever their accuracy or adequacy is questioned, and at least once every 6 mo. Immediately correct deficiencies, and recalibrate. Provide a record of calibration showing scales in compliance with ASTM C94 requirements. Check batching accuracy of volumetric water batching devices at least every 90 days. Check batching accuracy of chemical admixture dispensing devices at least every 6 mo. Perform daily checks as necessary to ensure measuring accuracy.

3.1.2. Volumetric Mixers. Provide volumetric mixers with rating plates defining the capacity and the performance of the mixer in accordance with the Volumetric Mixer Manufacturers Bureau or equivalent. Provide volumetric mixers that comply with ASTM C685. Provide test data showing mixers meet the uniformity test requirements of Tex-472-A.

Unless allowed on the plans or by the Engineer, volumetric truck (auger) mixers may not supply classes of concrete identified as structural concrete in Table 8.

3.1.3. Agitators and Truck and Stationary Mixers. Provide stationary and truck mixers capable of combining the ingredients of the concrete into a thoroughly mixed and uniform mass and capable of discharging the concrete so at least 5 of the 6 requirements of Tex-472-A are met.

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

Perform the mixer or agitator uniformity test at the full rated capacity of the equipment. Remove all equipment that fails the uniformity test from service.

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

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

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

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

Maintain hauling equipment clean and free of built-up concrete.

3.3. Testing Equipment. Furnish and maintain the following in accordance with the pertinent test procedure unless otherwise shown on the plans or specified:

- sieves necessary to perform aggregate gradation analysis when optimized aggregate gradation is specified,

- equipment necessary to perform Tex-415-A and Tex-422-A,
- equipment necessary to perform Tex-409-A or Tex-425-A,
- test molds,
- curing facilities,
- maturity meters if used, and
- wheelbarrow or other container acceptable for the sampling of the concrete.

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

## 4. CONSTRUCTION

4.1. **Classification of Concrete Mix Designs**. Provide classes of concrete meeting the requirements shown in Table 8.

A higher-strength class of concrete with equal or lower water-to-cementitious material (w/cm) ratio may be substituted for the specified class of concrete when approved.

4.2. **Mix Design Proportioning**. Furnish mix designs using ACI 211, Tex-470-A, or other approved procedures for the classes of concrete listed in Table 8 unless a design method is indicated on the plans. Perform mix design proportioning by absolute volume method unless otherwise approved. Perform cement replacement using equivalent weight method unless otherwise approved.

Do not exceed the maximum w/cm ratio listed in Table 8 when designing the mixture.

4.2.1. **Cementitious Materials**. Do not exceed 700 lb. of cementitious material per cubic yard of concrete unless otherwise specified or approved.

- Use cement of the same type and from the same source for monolithic placements.
- Do not use supplementary cementing materials when white hydraulic cement is specified.

Table 8
Concrete Classes

| Class of Concrete | Design Strength,[1] Min $f'_c$ (psi) | Max w/cm Ratio | Coarse Aggregate Grades[2,3,4] | Cement Types | Mix Design Options | Exceptions to Mix Design Options | General Usage[5] |
|---|---|---|---|---|---|---|---|
| A | 3,000 | 0.60 | 1–4, 8 | I, II, I/II, IL, IP, IS, IT, V | 1, 2, 4, & 7 | When the cementitious material content does not exceed 520 lb./cu. yd., Class C fly ash may be used instead of Class F fly ash. | Curb, gutter, curb & gutter, conc. retards, sidewalks, driveways, back-up walls, anchors, non-reinforced drilled shafts |
| B | 2,000 | 0.60 | 2–7 | | | | Riprap, traffic signal controller foundations, small roadside signs, and anchors |
| C[6] | 3,600 | 0.45 | 1–6 | I, II, I/II, IP, IS, IT,[7] V | 1–8 | | Drilled shafts, bridge substructure, bridge railing, culverts except top slab of direct traffic culverts, headwalls, wing walls, inlets, manholes, concrete traffic barrier (cast-in-place) |
| E | 3,000 | 0.50 | 2–5 | I, II, I/II, IL, IP, IS, IT,[7] V | 1–8 | When the cementitious material content does not exceed 520 lb./cu. yd., Class C fly ash may be used instead of Class F fly ash. | Seal concrete |
| F[6] | Note[8] | 0.45 | 2–5 | I, II, I/II, IP, IS, IT,[7] V | | | Railroad structures; occasionally for bridge piers, columns, or bents |

Table 8 (continued)
Concrete Classes

| Class of Concrete | Design Strength,[1] Min $f'_c$ (psi) | Max w/cm Ratio | Coarse Aggregate Grades[2,3,4] | Cement Types | Mix Design Options | Exceptions to Mix Design Options | General Usage[5] |
|---|---|---|---|---|---|---|---|
| H[6] | Note[8] | 0.45 | 3–6 | I, II, I/II, III, IP, IS, IT,[7] V | 1–5 | Do not use Type III cement in mass placement concrete. Up to 20% of blended cement may be replaced with listed SCMs when Option 4 is used for precast concrete. | Precast concrete, post-tension members |
| S[6] | 4,000 | 0.45 | 2–5 | I, II, I/II, IP, IS, IT,[7]V | 1–8 | | Bridge slabs, top slabs, approach slabs of direct traffic culverts |
| P | See Item 360, "Concrete Pavement." | 0.50 | 2–3 | I, II, I/II, IL, IP, IS, IT, V | 1–8 | When the cementitious material content does not exceed 520 lb./cu. yd., Class C fly ash may be used instead of Class F fly ash. | Concrete pavement |
| CO[6] | 4,600 | 0.40 | 6 | I, II, I/II, IP, IS, IT,[7] V | 1–8 | | Bridge deck concrete overlay |
| LMC[6] | 4,000 | 0.40 | 6–8 | | | | Latex-modified concrete overlay |
| SS[6] | 3,600 | 0.45 | 4–6 | | | Use a minimum cementitious material content of 658 lb./cu. yd. of concrete. | Slurry displacement shafts, underwater drilled shafts |
| K[6] | Note[8] | 0.40 | Note[8] | I, II, I/II, III IP, IS, IT,[7] V | | | Note[8] |
| HES | Note[8] | 0.45 | Note[8] | I, IL, II, I/II, III | | Mix design options do not apply. 700 lb. of cementitious material per cubic yard limit does not apply. | Concrete pavement, concrete pavement repair |
| "X" (HPC)[6,9,10] | Note[11] | 0.45 | Note[11] | I, II, I/II, III IP, IS, IT,[7] V | 1–5, & 8 | Maximum fly ash replacement for Options 1 and 3 may be increased to 45%. Up to 20% of a blended cement may be replaced with listed SCMs for Option 4. Do not use Option 8 for precast concrete. | |
| "X" (SRC)[6,9,10] | Note[11] | 0.45 | Note[11] | I/II, II, IP, IS, IT,[7] V | 1–4 , & 7 | Do not use Class C Fly Ash Type III-MS may be used where allowed. Type I and Type III cements may be used with Options 1–3, with a maximum w/cm of 0.40. Up to 20% of blended cement may be replaced with listed SCMs when Option 4 is used for precast concrete. Do not use Option 7 for precast concrete. | |

1. Design strength must be attained within 56 days.
2. Do not use Grade 1 coarse aggregate except in massive foundations with 4 in. minimum clear spacing between reinforcing steel bars, unless otherwise permitted. Do not use Grade 1 aggregate in drilled shafts.
3. Use Grade 8 aggregate in extruded curbs unless otherwise approved.
4. Other grades of coarse aggregate maybe used in non-structural concrete classes when allowed by the Engineer.
5. For information only.
6. Structural concrete classes.
7. Do not use Type IT cements containing > 5% limestone.
8. As shown on the plans or specified.
9. "X" denotes class of concrete shown on the plans or specified.
10. (HPC): High Performance Concrete, (SRC): Sulfate Resistant Concrete.
11. Same as class of concrete shown on the plans.

4.2.2. Aggregates. Recycled crushed hydraulic cement concrete may be used as a coarse or fine aggregate in Class A, B, E, and P concrete. Limit recycled crushed concrete fine aggregate to a maximum of 20% of the fine aggregate.

Use light-colored aggregates when white hydraulic cement is specified.

Use fine aggregate with an acid insoluble residue of at least 60% by weight when tested in accordance with Tex-612-J in all concrete subject to direct traffic.

Use the following equation to determine if the aggregate combination meets the acid insoluble residue requirement when blending fine aggregate or using an intermediate aggregate:

$$\frac{(A_1 \times P_1)+(A_2 \times P_2)+(A_{ia} \times P_{ia})}{100} \geq 60\%$$

where:
$A_1$ = acid insoluble (%) of fine aggregate 1
$A_2$ = acid insoluble (%) of fine aggregate 2
$A_{ia}$ = acid insoluble (%) of intermediate aggregate passing the 3/8 in. sieve
$P_1$ = percent by weight of fine aggregate 1 of the fine aggregate blend
$P_2$ = percent by weight of fine aggregate 2 of the fine aggregate blend
$P_{ia}$ = percent by weight of intermediate aggregate passing the 3/8 in. sieve

Alternatively to the above equation, blend fine aggregate with a micro-deval loss of less than 12%, when tested in accordance with Tex-461-A, with at least 40% of a fine aggregate with an acid insoluble residue of at least 60%.

4.2.3. Chemical Admixtures. Do not use Type C, Type E, Type F, or Type G admixtures in Class S bridge deck concrete. Do not use chemical admixtures containing calcium chloride in any concrete.

Use a 30% calcium nitrite solution when a corrosion-inhibiting admixture is required. The corrosion-inhibiting admixture must be set neutral unless otherwise approved. Dose the admixture at the rate of gallons of admixture per cubic yard of concrete shown on the plans.

4.2.4. Air Entrainment. Use an approved air-entraining admixture when air-entrained concrete is specified, or when an air-entraining admixture is used at the Contractor's option, and do not exceed the manufacturer's recommended dosage. Ensure the minimum entrained air content is at least 3.0% for all classes of concrete except Class P when air-entrained concrete is specified, during trial batch, or when providing previous field data.

4.2.5. Slump. Provide concrete with a slump in accordance with Table 9 unless otherwise specified. When approved, the slump of a given concrete mix may be increased above the values shown in Table 9 using chemical admixtures, provided the admixture-treated concrete has the same or lower water-to-cementitious material ratio and does not exhibit segregation or excessive bleeding. Request approval to exceed the slump limits in Table 9 sufficiently in advance for proper evaluation by the Engineer.

Perform job-control testing of slump in accordance with Section 421.4.8.3.1., "Job-Control Testing."

Table 9
Placement Slump Requirements

| General Usage[1] | Placement Slump Range,[2] in. |
|---|---|
| Walls (over 9 in. thick), caps, columns, piers, approach slabs, concrete overlays | 3 to 5 |
| Bridge slabs, top slabs of direct traffic culverts, latex-modified concrete for bridge deck overlays | 3 to 5-1/2 |
| Inlets, manholes, walls (less than 9 in. thick), bridge railing, culverts, concrete traffic barrier, concrete pavement (formed), seal concrete | 4 to 5-1/2 |
| Precast concrete | 4 to 9 |
| Underwater concrete placements | 6 to 8-1/2 |
| Curb, gutter, curb and gutter, concrete retards, sidewalk, driveways, anchors, riprap, small roadside sign foundations, concrete pavement repair, concrete repair | As approved |

1. For information only.
2. For fiber reinforced concrete, perform slump before addition of fibers.

4.2.6. Mix Design Options.

4.2.6.1. Option 1. Replace 20% to 35% of the cement with Class F fly ash.

4.2.6.2. Option 2. Replace 35% to 50% of the cement with slag cement or MFFA.

4.2.6.3. Option 3. Replace 35% to 50% of the cement with a combination of Class F fly ash, slag cement, MFFA, UFFA, metakaolin, or silica fume; however, no more than 35% may be fly ash, and no more than 10% may be silica fume.

4.2.6.4. Option 4. Use Type IP, Type IS, or Type IT cement as allowed in Table 5 for each class of concrete. Up to 10% of a Type IP, Type IS, or Type IT cement may be replaced with Class F fly ash, slag cement, or silica fume. Use no more than 10% silica fume in the final cementitious material mixture if the Type IT cement contains silica fume, and silica fume is used to replace the cement.

4.2.6.5. Option 5. Replace 35% to 50% of the cement with a combination of Class C fly ash and at least 6% of silica fume, UFFA, or metakaolin. However, no more than 35% may be Class C fly ash, and no more than 10% may be silica fume.

4.2.6.6. Option 6. Use a lithium nitrate admixture at a minimum dosage determined by testing conducted in accordance with Tex-471-A, "Lithium Dosage Determination Using Accelerated Mortar Bar Testing." Before use of the mix, provide an annual certified test report signed and sealed by a licensed professional engineer, from a laboratory on the Department's MPL, certified by the Construction Division as being capable of testing according to Tex-471-A, "Lithium Dosage Determination Using Accelerated Mortar Bar Testing."

4.2.6.7. Option 7. Ensure the total alkali contribution from the cement in the concrete does not exceed 3.5 lb. per cubic yard of concrete when using hydraulic cement not containing SCMs calculated as follows:

$$\text{lb. alkali per cu. yd.} = \frac{(\text{lb. cement per cu. yd.}) \times (\%\ Na_2O \text{ equivalent in cement})}{100}$$

4.2.6.8. Option 8. Perform annual testing as required for any deviations from Options 1–5 or use mix design options listed in Table 10. Laboratories performing ASTM C1260, ASTM C1567, and ASTM C1293 testing must be listed on the Department's MPL. Before use of the mix, provide a certified test report signed and sealed by a licensed professional engineer demonstrating the proposed mixture conforms to the requirements of Table 10.

Provide a certified test report signed and sealed by a licensed professional engineer, when HPC is required, and less than 20% of the cement is replaced with SCMs, demonstrating ASTM C1202 test results indicate the permeability of the concrete is less than 1,500 coulombs tested immediately after either of the following curing schedules:

- Moisture cure specimens 56 days at 73°F.
- Moisture cure specimens 7 days at 73°F followed by 21 days at 100°F.

Table 10
Option 8 Testing and Mix Design Requirements

| Scenario | ASTM C1260 Result | | Testing Requirements for Mix Design Materials or Prescriptive Mix Design Options[1] |
|---|---|---|---|
| | Mix Design Fine Aggregate | Mix Design Coarse Aggregate | |
| A | > 0.10% | > 0.10% | Determine the dosage of SCMs needed to limit the 14-day expansion of each aggregate[2] to 0.08% when tested individually in accordance with ASTM C1567, or Use a minimum of 40% Class C fly ash with a maximum CaO[3] content of 25%. |
| B | ≤ 0.10% | ≤ 0.10% | Use a minimum of 40% Class C fly ash with a maximum CaO[3] content of 25%, or Use any ternary combination which replaces 35% to 50% of cement. |
| | ≤ 0.10% | ASTM C1293 1 yr. Expansion ≤ 0.04% | Use a minimum of 20% of any Class C fly ash, or Use any ternary combination which replaces 35% to 50% of cement. |
| C | ≤ 0.10% | > 0.10% | Determine the dosage of SCMs needed to limit the 14-day expansion of coarse and intermediate[2] aggregate to 0.08% when tested individually in accordance with ASTM C1567, or Use a minimum of 40% Class C fly ash with a maximum CaO[3] content of 25%. |
| D | > 0.10% | ≤ 0.10% | Use a minimum of 40% Class C fly ash with a maximum CaO[3] content of 25%, or Use any ternary combination which replaces 35% to 50% of cement. |
| | > 0.10% | ASTM C1293 1 yr. Expansion ≤ 0.04% | Determine the dosage of SCMs needed to limit the 14-day expansion of fine aggregate to 0.08% when tested in accordance with ASTM C1567. |

1. Do not use Class C fly ash if the ASTM C1260 value of the fine, intermediate, or coarse aggregate is 0.30% or greater, unless the fly ash is used as part of a ternary system.
2. Intermediate size aggregates will fall under the requirements of mix design coarse aggregate.
3. Average the CaO content from the previous ten values as listed on the mill certificate.

4.2.7. Optimized Aggregate Gradation (OAG) Concrete. The gradation requirements in Table 3 and Table 4 do not apply when OAG concrete is specified or used by the Contractor unless otherwise shown on the plans. Use Tex-470-A to establish the optimized aggregate gradation. Use at least 420 lb. per cubic yard of cementitious material when OAG concrete is used unless otherwise approved. Use a coarse aggregate with a maximum nominal size of 1-1/2 in. for Class P concrete. Use a coarse aggregate for all other classes of concrete with a maximum nominal size not larger than:

- 1/5 the narrowest dimension between sides of forms, or
- 1/3 the depth of slabs, or
- 3/4 the minimum clear spacing between individual reinforcing bars or wires, bundles of bars, individual tendons, bundled tendons, or ducts.

Make necessary adjustments to individual aggregate stockpile proportions during OAG concrete production when the gradation deviates from the optimized gradation requirements.

4.2.8. Self-Consolidating Concrete (SCC). Provide SCC meeting the following requirements shown in Table 11 when approved for use in precast concrete. Use concrete with a slump flow that can be placed without vibration and will not segregate or excessively bleed.

Request approval to exceed the slump flow limits sufficiently in advance for proper evaluation by the Engineer.

Table 11
Mix Design Requirements for SCC

| Tests | Test Method | Acceptable Limits |
|---|---|---|
| Slump Flow for Precast Concrete | ASTM C1611 | 22 to 27[1] |
| | | |
| $T_{50}$, sec | ASTM C1611 | 2 to 7 |
| VSI Rating | ASTM C1611 | 0 or 1 |
| Passing Ability, in. | ASTM C1621 | ≤ 2 |
| Segregation Column, % | ASTM C1610 | ≤ 10 |
| Bleeding, % | ASTM C232 | ≤ 2.5 |

1. These slump flow limits are generally acceptable for most applications. However, slump flow limits may be adjusted during mix design approval process and when approved by the Engineer.

4.3. Concrete Trial Batches. Perform preliminary and final trial batches when required by the plans, or when previous satisfactory field data is not available. Submit previous satisfactory field data to the Engineer showing the proposed mix design conforms to specification requirements when trial batches are not required and before concrete is placed.

Perform preliminary and final trial batches for all self-consolidating concrete mix designs.

4.3.1. Preliminary Trial Batches. Perform all necessary preliminary trial batch testing when required, and provide documentation including mix design, material proportions, and test results substantiating the mix design conforms to specification requirements.

4.3.2. Final Trial batches. Make all final trial batches using the proposed ingredients in a mixer that is representative of the mixers to be used on the job when required. Make the batch size at least 50% of the mixer's rated capacity. Perform fresh concrete tests for air content and slump, and make, cure, and test strength specimens for compliance with specification requirements. Test at least one set of design strength specimens, consisting of 2 specimens per set, at 7-day, 28-day, and at least one additional age unless otherwise directed. Before placing, provide the Engineer the option of witnessing final trial batches, including the testing of the concrete. If not provided this option, the Engineer may require additional trial batches, including testing, before the concrete is placed.

Conduct all testing listed in Table 11 when performing trial batches for self-consolidating concrete. Make an additional mixture with 3% more water than the preliminary trial batch. Make necessary adjustments to the mix design if this additional mixture does not meet requirements of Table 11. Cast and evaluate mock-ups for precast concrete that are representative of the actual product as directed. Provide the Engineer the option of witnessing final trial batches, including the testing of the concrete and the casting of the mock-ups before placement. If not provided this option, the Engineer may require additional trial batches, including testing and mock-ups, before the concrete is placed.

Establish 7-day compressive strength target values using the following formula for each Class A, B, and E concrete mix designs to be used:

$$\text{Target value} = \text{Minimum design strength} \times \frac{\text{7 - day avg. trial batch strength}}{\text{28 - day avg. trial batch strength}}$$

Submit previous satisfactory field data, data from a new trial batch, or other evidence showing the change will not adversely affect the relevant properties of the concrete when changes are made to the type, brand, or source of aggregates, cement, SCM, water, or chemical admixtures. Submit the data for approval before making changes to the mix design. A change in vendor does not necessarily constitute a change in materials or source. The Engineer may waive new trial batches when there is a prior record of satisfactory performance with the ingredients. During concrete production, dosage changes of chemical admixtures used in the trial batches will not require a re-evaluation of the mix design.

The Contractor has the option of performing trial batches in conjunction with concrete placements except for SCC mixtures, when new trial batches are required during the course of the project. If the concrete fails to meet any requirement, the Engineer will determine acceptability and payment adjustments.

Establish the strength–maturity relationship in accordance with Tex-426-A when the maturity method is specified or permitted. When using the maturity method, any changes in any of the ingredients, including changes in proportions, will require the development of a new strength–maturity relationship for the mix.

4.3.3. Mix Design of Record. Once a trial batch or previously satisfactory field data substantiates the mix design, the proportions and mixing methods used become the mix design of record. Do not exceed mix design water-to-cement ratio.

4.4. Production Testing.

4.4.1. Aggregate Moisture Testing. Determine moisture content per Tex-409-A or Tex-425-A for coarse, intermediate, and fine aggregates at least twice a week, when there is an apparent change, or for new shipments of aggregate. When aggregate hoppers or storage bins are equipped with properly maintained electronic moisture probes for continuous moisture determination, moisture tests per Tex-409-A or Tex-425-A are not required. Electronic moisture probes, however, must be verified at least every 90 days against Tex-409-A and be accurate to within 1.0% of the actual moisture content.

When producing SCC, and when aggregate hoppers or storage bins are not equipped with electric moisture probes, determine the moisture content of the aggregates before producing the first concrete batch each day. Thereafter, determine the moisture content every 4 hr. or when there is an apparent change while SCC is being produced.

4.4.2. Aggregate Gradation Testing. Perform a sieve analysis in accordance with Tex-401-A on each stockpile used in the blend at least one day before producing OAG concrete when producing optimized aggregate gradation concrete. Perform sieve analysis on each stockpile after every 10,000 cubic yards of OAG concrete produced. Provide sieve analysis data to the Engineer.

4.5. Measurement of Materials.

4.5.1. Non-Volumetric Mixers. Measure aggregates by weight. Correct batch weight measurements for aggregate moisture content. Measure mixing water, consisting of water added to the batch, ice added to the batch, water occurring as surface moisture on the aggregates, and water introduced in the form of admixtures, by volume or weight. Measure ice by weight. Measure cement and supplementary cementing materials in a hopper and on a separate scale from those used for other materials. Measure the cement first when measuring the cumulative weight. Measure concrete chemical admixtures by weight or volume. Measure batch materials within the tolerances of Table 12.

Table 12
Mix Design Batching Tolerances—Non-Volumetric Mixers

| Material | Tolerance (%) |
|---|---|
| Cement, wt. | –1 to +3 |
| SCM, wt. | –1 to +3 |
| Cement + SCM (cumulative weighing), wt. | –1 to +3 |
| Water, wt. or volume | ±3[1] |
| Fine aggregate, wt. | ±2 |
| Coarse aggregate, wt. | ±2 |
| Fine + coarse aggregate (cumulative weighing), wt. | ±1 |
| Chemical admixtures, wt. or volume | ±3 |

1. Allowable deviation from target weight not including water withheld or moisture in the aggregate. The Engineer will verify the water-to-cementitious material ratio is within specified limits.

Ensure the quantity measured, when measuring cementitious materials at less than 30% of scale capacity, is accurate to not less than the required amount and not more than 4% in excess. Ensure the cumulative quantity, when measuring aggregates in a cumulative weigh batcher at less than 30% of the scale capacity,

is measured accurate to ±0.3% of scale capacity or ±3% of the required cumulative weight, whichever is less.

Measure cement in number of bags under special circumstances when approved. Use the weights listed on the packaging. Weighing bags of cement is not required. Ensure fractional bags are not used except for small hand-mixed batches of approximately 5 cu. ft. or less and when an approved method of volumetric or weight measurement is used.

4.5.2. Volumetric Mixers. Provide an accurate method of measuring all ingredients by volume, and calibrate equipment to assure correct measurement of materials within the specified tolerances. Base tolerances on volume–weight relationship established by calibration, and measure the various ingredients within the tolerances of Table 13. Correct batch measurements for aggregate moisture content.

Table 13
Mix Design Batching Tolerances—Volumetric Mixers

| Material | Tolerance |
|---|---|
| Cement, wt. % | 0 to +4 |
| SCM, wt. % | 0 to +4 |
| Fine aggregate, wt. % | ±2 |
| Coarse aggregate, wt. % | ±2 |
| Admixtures, wt. or volume % | ±3 |
| Water, wt. or volume % | ±1 |

4.6. Mixing and Delivering Concrete.

4.6.1. Mixing Concrete. Operate mixers and agitators within the limits of the rated capacity and speed of rotation for mixing and agitation as designated by the manufacturer of the equipment. Provide concrete in a thoroughly mixed and uniform mass with a satisfactory degree of uniformity when tested in accordance with Tex-472-A.

Do not top-load new concrete onto returned concrete.

Adjust mixing times and batching operations as necessary when the concrete contains silica fume to ensure the material is completely and uniformly dispersed in the mix. The dispersion of the silica fume within the mix will be verified by the Construction Division, Materials and Pavements Section, using cylinders made from trial batches. Make necessary changes to the batching operations, if uniform dispersion is not achieved, until uniform and complete dispersion of the silica fume is achieved.

Mix concrete by hand methods or in a small motor-driven mixer when permitted, for small placements of less than 2 cu. yd. For such placements, proportion the mix by volume or weight.

4.6.2. Delivering Concrete. Deliver concrete to the project in a thoroughly mixed and uniform mass, and discharge the concrete with a satisfactory degree of uniformity. Conduct testing in accordance with Tex-472-A when there is a reason to suspect the uniformity of concrete and as directed.

Maintain concrete delivery and placement rates sufficient to prevent cold joints.

Adding chemical admixtures or the portion of water withheld is only permitted at the jobsite, under the supervision of the Engineer, to adjust the slump or slump flow of the concrete. Do not add water or chemical admixtures to the batch after more than an amount needed to conduct slump testing has been discharged. Turn the drum or blades at least 30 additional revolutions at mixing speed to ensure thorough and uniform mixing of the concrete. When this water is added, do not exceed the approved mix design water-to-cementitious material ratio.

Before unloading, furnish the delivery ticket for the batch of concrete containing the information required on Department Form 596, “Concrete Batch Ticket.” The Engineer will verify all required information is provided on the delivery tickets. The Engineer may suspend concrete operations until the corrective actions are

implemented if delivery tickets do not provide the required information. The Engineer will verify the design water-to-cementitious material ratio is not exceeded.

Begin the discharge of concrete delivered in truck mixers within the times listed in Table 14. Concrete may be discharged after these times provided the concrete temperature and slump meet the requirements listed in this Item and other pertinent Items. Perform these tests with certified testing personnel per Section 421.4.8.1., "Certification of Testing Personnel." Provide the Engineer the option of witnessing testing of the concrete. If not provided this option, the Engineer may require additional testing before the concrete is placed.

Table 14
Concrete Discharge Times

| Fresh Concrete Temperature, °F | Max Time After Batching for Concrete Not Containing Type B or D Admixtures, min. | Max Time After Batching for Concrete Containing Type B or D Admixtures,[1] min. |
|---|---|---|
| 90 and above | 45 | 75 |
| 75 ≤ T < 90 | 60 | 90 |
| T < 75 | 90 | 120 |

1. Concrete must contain at least the minimum manufacturer's recommended dosage of Type B or D admixture.

4.7. Placing, Finishing, and Curing Concrete. Place, finish, and cure concrete in accordance with the pertinent Items.

4.8. Sampling and Testing of Concrete. Unless otherwise specified, all fresh and hardened concrete is subject to testing as follows:

4.8.1. Certification of Testing Personnel. Contractor personnel performing testing must be either ACI-certified or qualified by a Department-recognized equivalent written and performance testing program for the tests being performed. Personnel performing these tests are subject to Department approval. Use of a commercial laboratory is permitted at the Contractor's option. All personnel performing testing using the maturity method must be qualified by a training program recognized by the Department before using this method on the job.

4.8.2. Fresh Concrete. Provide safe access and assistance to the Engineer during sampling. Fresh concrete will be sampled for testing at the discharge end if using belt conveyors or pumps. When it is impractical to sample at the discharge end, a sample will be taken at the time of discharge from the delivery equipment and correlation testing will be performed and documented to ensure specification requirements are met at the discharge end.

4.8.3. Testing of Fresh Concrete. Test for the fresh properties listed in Table 15.

Table 15
Fresh Concrete Tests

| Tests | Test Methods |
|---|---|
| Slump[1] | Tex-415-A |
| Temperature[1] | Tex-422-A |
| Air Content[2] | Tex-414-A, Tex-416-A or ASTM C457 |

1. Job-control testing performed by the Contractor.
2. Only required during concrete trial batch when air-entrained concrete is specified on the plans.

Concrete with a slump lower than the minimum placement slump in Table 9 after the addition of all water withheld, or concrete exhibiting segregation and excessive bleeding may be rejected.

4.8.3.1. Job-Control Testing. Perform job-control concrete temperature and slump testing as specified in Table 16 unless otherwise specified. Provide the Engineer the opportunity to witness the testing. The Engineer may require a retest if not given the opportunity to witness. Immediately notify the Engineer of any concrete temperature or slump nonconformity issues. Furnish a copy of all test results to the Engineer daily.

Table 16
Job-Control Testing Frequencies

| Concrete Placements | Frequency |
|---|---|
| Bridge Deck Placements | Test the first few loads, then every fifth load delivered. |
| All Other Structural Class Concrete Placements | One test every 60 cu. yd. or fraction thereof. |
| Non-Structural Class Concrete Placements | One test every 180 cu. yd. or fraction thereof. |

Immediately resample and retest the concrete slump when the concrete exceeds the slump range at time of placement. If the concrete exceeds the slump range after the retest, and is used at the Contractor's option, the Engineer will make strength specimens as specified in Article 421.5., "Acceptance of Concrete."

4.8.3.2. Strength Specimen Handling. Remove specimens from their molds and deliver Department test specimens to curing facilities within 24 to 48 hr. after molding, in accordance with pertinent test procedures unless otherwise shown on the plans or directed. Clean and prepare molds for reuse if necessary.

## 5. ACCEPTANCE OF CONCRETE

The Engineer will sample and test the fresh and hardened concrete for acceptance. The test results will be reported to the Contractor and the concrete supplier. Investigate the quality of the materials, the concrete production operations, and other possible problem areas to determine the cause for any concrete that fails to meet the required strengths as outlined below. Take necessary actions to correct the problem including redesign of the concrete mix. The Engineer may suspend all concrete operations under the pertinent Items if the Contractor is unable to identify, document, and correct the cause of the low strengths in a timely manner. Resume concrete operations only after obtaining approval for any proposed corrective actions. Concrete failing to meet the required strength as outlined below will be evaluated using the procedures listed in Article 421.6., "Measurement and Payment."

5.1. Structural Concrete. For concrete classes identified as structural concrete in Table 8, the Engineer will make and test 7-day and 28-day specimens. Acceptance will be based on attaining the design strength given in Table 8.

5.2. Class P and Class HES. The Engineer will base acceptance in accordance with Item 360, "Concrete Pavement,".

5.3. All Other Concrete. For concrete classes not identified as structural concrete in Table 8, the Engineer will make and test 7-day specimens. The Engineer will base acceptance on the 7-day target value established in accordance with Section 421.4.3., "Concrete Trial Batches."

## 6. 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.

The following procedure will be used to evaluate concrete where one or more project acceptance test specimens fail to meet the required design strength specified in this Item or on the plans:

- The concrete for a given placement will be considered structurally adequate and accepted at full price if the average of all test results for specimens made at the time of placement meets the required design strength provided no single test result is less than 85% of the required design strength.
- The Engineer will perform a structural review of the concrete to determine its adequacy to remain in service if the average of all test results for specimens made at the time of placement is less than the required design strength or if any test results are less than 85% of the required design strength. If the in-situ concrete strength is needed for the structural review, take cores at locations designated by the

Engineer in accordance with Tex-424-A. The Engineer will test the cores. The coring and testing will be at the Contractor's expense.

- If all of the tested cores meet the required design strength, the concrete will be paid for at full price.
- If any of the tested cores do not meet the required design strength, but the average strength attained is determined to be structurally adequate, the Engineer will determine the limits of the pay adjustment using the following formula:

$$A = B_p\left[-5.37\left(\frac{S_a}{S_s}\right)^2 + 11.69\left(\frac{S_a}{S_s}\right) - 5.32\right]$$

where:
$A$ = Amount to be paid per unit of measure for the entire placement in question
$S_a$ = Actual average strength from cylinders or cores. Use values from cores, if taken.
$S_s$ = Minimum required strength (specified)
$B_p$ = Unit Bid Price

- If the structural review determines the concrete is not adequate to remain in service, the Engineer will determine the limits of the concrete to be removed.
- The decision to reject structurally inadequate concrete or to apply the pay adjustment factor will be made no later than 56 days after placement.

# 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"
- 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 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.

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.

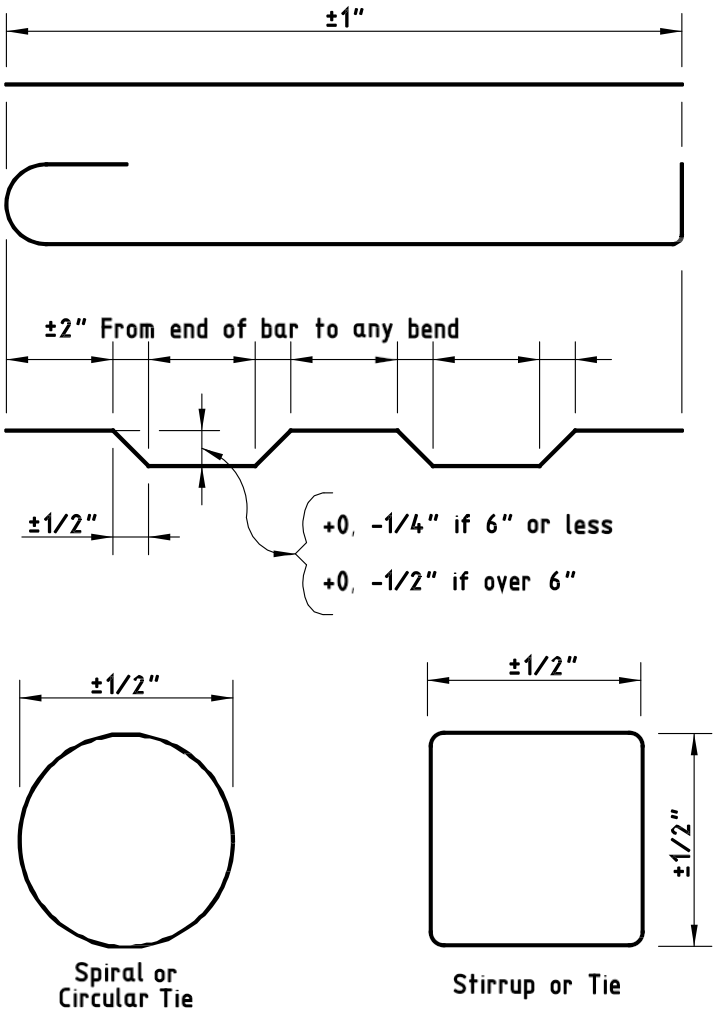


Figure 1
Fabrication Tolerances for Bars

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. 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 441
# Steel Structures

## 1. DESCRIPTION

Fabricate and erect structural steel and other metals used for steel structures or for steel portions of structures.

## 2. MATERIALS

2.1. **Base Metal**. Use metal that meets Item 442, "Metal for Structures."

2.2. **Approved Electrodes and Flux-Electrode Combinations**. Use only electrodes and flux-electrode combinations found on the Department's MPL. To request a product be added to this list or to renew an expired approval, electronically submit a current Certificate of Conformance containing all tests required by the applicable AWS A5 specification according to the applicable welding code (for most construction, AASHTO/AWS D1.5, *Bridge Welding Code*, or AWS D1.1*, Structural Welding Code—Steel*) to the Construction Division.

2.3. **High-Strength Bolts**. Use fasteners that meet Item 447, "Structural Bolting." Use galvanized fasteners on field connections of bridge members when ASTM A325 bolts are specified and steel is painted.

2.4. **Paint Systems**. Provide the paint system (surface preparation, primer, intermediate, and appearance coats as required) shown on the plans. Provide System IV if no system is specified.

2.4.1. **Standard Paint Systems**. Standard paint systems for painting new steel include the following:

2.4.1.1. **System III-B**. Provide paint in accordance with DMS-8101, "Structural Steel Paints-Performance." Provide inorganic zinc (IOZ) prime coat, epoxy intermediate coat, and urethane appearance coat for all outer surfaces except those to be in contact with concrete. Provide epoxy zinc prime coat for touchup of IOZ.

2.4.1.2. **System IV**. Provide paint in accordance with DMS-8101, "Structural Steel Paints-Performance." Provide IOZ prime coat and acrylic latex appearance coat for all outer surfaces except those to be in contact with concrete. Provide epoxy zinc prime coat for touchup of IOZ.

2.4.2. **Paint Inside Tub Girders and Closed Boxes**. Provide a white polyamide cured epoxy for all interior surfaces, including splice plate but excluding the faying surfaces, unless otherwise shown on the plans. Provide IOZ primer meeting the requirements of DMS-8101, "Structural Steel Paints—Performance," to all interior faying surfaces and splice plates.

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

2.4.4. **Galvanizing**. Provide galvanizing, as required, in accordance with Item 445, "Galvanizing."

2.4.5. **Paint over Galvanizing**. Paint over galvanized surfaces, when required, in accordance with Item 445, "Galvanizing."

2.4.6. **Field Painting**. Provide field paint, as required, in accordance with Item 446, "Field Cleaning and Painting Steel."

# 3. CONSTRUCTION

## 3.1. General Requirements.

**3.1.1. Applicable Codes.** Perform all fabrication of bridge members in accordance with AASHTO/NSBA Steel Bridge Collaboration S2.1. Follow all applicable provisions of the appropriate AWS code (D1.5 or D1.1) except as otherwise noted on the plans or in this Item. Weld sheet steel (thinner than 1/8 in.) in accordance with ANSI/AWS D1.3, Structural Welding Code—Sheet Steel. Unless otherwise stated, requirements of this Item are in addition to the requirements of S2.1 for bridge members. Follow the more stringent requirement in case of a conflict between this Item and S2.1. Perform all bolting in accordance with Item 447, "Structural Bolting."

Fabricate railroad underpass structures in accordance with the latest AREMA *Manual for Railway Engineering* and this Item. In the case of a conflict between this Item and the AREMA manual, the more stringent requirements apply.

**3.1.2. Notice of Fabrication.** Give adequate notice before commencing fabrication work as specified in Table 1. Include a schedule for all major fabrication processes and dates when inspections are to occur.

Table 1
Notice of Beginning Work

| Plant Location | Notice Required |
|---|---|
| In Texas | 7 days |
| In the contiguous United States | 21 days |
| Outside the contiguous United States | 60 days |

Perform no Department work in the plant before the Engineer authorizes fabrication. The Contractor must bear all Department travel costs when changes to their fabrication or inspection schedules are not adequately conveyed to the Department.

When any structural steel is fabricated outside of the contiguous 48 states, the additional cost of inspection will be in accordance with Article 6.4., "Sampling, Testing, and Inspection."

**3.1.3. Bridge Members.** Primary bridge members include:

- web and flanges of plate, tub, and box girders;
- rolled beams and cover plates;
- floor beam webs and flanges;
- arch ribs and arch tie beams or girders;
- truss members;
- diaphragm members for curved plate girders or beams;
- pier diaphragm members for tub girders;
- splice plates for primary members; and
- any other member designated as "primary" or "main" on the plans.

Secondary bridge members include:

- bracing (diaphragms, cross frames, and lateral bracing); and
- all other miscellaneous bridge items not considered primary bridge members.

**3.1.4. Responsibility.** The Contractor is responsible for the correctness and completeness of shop drawings and for the fit of shop and field connections.

3.1.5. Qualification of Plants and Personnel.

3.1.5.1. Plants. Fabrication plants that produce bridge members must be approved in accordance with DMS-7370, "Steel Bridge Member Fabrication Plant Qualification." The Department's MPL has a list of approved bridge member fabrication plants.

Fabrication plants that produce non-bridge steel members listed below must be approved in accordance with DMS-7380, "Steel Non-Bridge Member Fabrication Plant Qualification." The Construction Division maintains a list of approved non-bridge fabrication plants for the following items:

- Roadway Illumination Poles
- High Mast Illumination Poles
- High Mast Rings and Support Assemblies
- Overhead Sign Support Structures
- Traffic Signal Poles
- Intelligent Transportation System (ITS) Poles

The Department will evaluate non-bridge member fabrication plants for competence of the plant, equipment, organization, experience, knowledge, and personnel to produce acceptable work.

3.1.5.2. Personnel. Provide a QC staff qualified in accordance with the applicable AWS code. Provide an adequate number of qualified QC personnel for each specific production operation. QC must be on-site and independent of production personnel, as the Engineer determines. QC personnel must be proficient in utilizing the applicable plans, specifications, and test methods, and in verifying compliance with the plant QC and production procedures. Welding inspectors must be current AWS Certified Welding Inspectors for bridge member plants, and for non-bridge member plants requiring Department approval per DMS-7380, "Steel Non-Bridge Member Fabrication Plant Qualification." The QC staff must provide inspection of all materials and workmanship before the Department's inspection. Provide the Department inspector with adequate personnel and equipment needed to move material for inspection access. QC is solely the Contractor's responsibility.

3.1.5.3. Nondestructive Testing (NDT). Personnel performing NDT must be qualified in accordance with the applicable AWS code and the employer's Written Practice. Level III personnel who qualify AS Level I and Level II inspectors must be certified by ASNT for which the NDT Level III is qualified. Testing agencies and individual third-party contractors must also successfully complete periodic audits for compliance, performed by the Department. In addition, ultrasound technicians must pass a hands-on test the Construction Division administers. This will remain current provided they continue to perform testing on Department materials as evidenced by test reports requiring their signature. A technician who fails the hands-on test must wait 6 months before taking the test again. Qualification to perform ultrasonic testing will be revoked when the technician's employment is terminated or when the technician goes 6 months without performing a test on a Department project. The technician must pass a new hands-on test to be re-certified.

3.1.5.4. Welding Procedure Specifications Qualification Testing. For bridge member fabrication, laboratories performing welding procedure specifications (WPSs) qualified by testing must be approved in accordance with DMS-7360, "Qualification Procedure for Laboratories Performing Welding Procedure Qualification Testing." The Department's MPL has a list of laboratories approved to perform WPS qualification testing.

3.1.6. Drawings.

3.1.6.1. Erection Drawings. Submit erection drawings prepared by a licensed professional engineer, including calculations, for approval in accordance with Item 5, "Control of the Work," at least 4 weeks before erecting any portion of field-spliced (welded or bolted) girders, railroad underpasses, trusses, arches, or other members for which erection drawings are required on the plans. Include drawings and calculations for any temporary structures used to support partially erected members. Erection drawings are not required for rolled I-beam units unless otherwise noted on the plans.

Prepare erection drawings following the procedures outlined in Section 2.2 of the AASHTO/NSBA Steel Bridge Collaboration S10.1. As a minimum, include:

- plan of work area showing structure location relative to supports and all obstructions;
- equipment to be used including allowable load information;
- erection sequence for all pieces;
- member weights and center of gravity location of pieces to be lifted;
- locations of cranes, holding cranes, and temporary supports (falsework), including when to release load from temporary supports and holding cranes;
- details of falsework including specific bracing requirements with maximum allowable design wind speed clearly indicated;
- girder lifting points;
- diaphragm and bracing requirements; and
- minimum connection requirements when more than the standard requirements.

Perform girder erection analyses using UT-Lift and UT-Bridge software available on the Department's website or other suitable commercial software. Ensure temporary stresses in members being erected will not cause permanent damage and that stability is maintained throughout the erection operations. Provide actual input files and output results from UT-Lift and UT-Bridge, or graphical and hard copy results from commercial software programs.

Do not proceed if site conditions differing from those depicted on the approved erection drawings could affect temporary support stresses, erected girders, or public safety in any manner. Revise erection drawings and resubmit to the Engineer for approval before proceeding if site conditions could affect these things.

3.1.6.2. Shop Drawings. Prepare and electronically submit shop drawings before fabrication for each detail of the general plans requiring the use of structural steel, forgings, wrought iron, or castings as documented in the *Guide to Electronic Shop Drawing Submittal* available on the Bridge Division website and as directed for other items the standard specifications require.

Indicate joint details on shop drawings for all welds. Provide a title block on each sheet in the lower right corner that includes:

- project identification data including federal and state project numbers,
- sheet numbering for the shop drawings,
- name of the structure or stream for bridge structures,
- name of owner or developer,
- name of the fabricator or supplier, and
- name of the Contractor.

Provide one set of 11 × 17-in. approved shop drawings in hardcopy to the Department for the inspector at the fabrication plant.

3.1.6.2.1. Bridge Members. Prepare drawings in accordance with AASHTO/NSBA Steel Bridge Collaboration G1.3, "Shop Detail Drawing Presentation" unless otherwise approved. Print a bill of material on each sheet, including the Charpy V-Notch (CVN) and fracture-critical requirements, if any, for each piece. Indicate fracture-critical areas of members.

3.1.6.2.2. Non-Bridge Members. Furnish shop drawings for non-bridge members when required by the plans or pertinent Items.

3.1.7. Welding Procedure Specifications (WPSs). Submit WPSs and test reports in accordance with the applicable AWS code to the Construction Division before fabrication begins, and notify the Engineer which procedures will be used for each joint or joint type. Do not begin fabrication until the Engineer approves WPSs.

Post the approved WPSs for the welding being performed on each welding machine, or use another approved method of ensuring the welder has access to the procedure information at all times.

3.1.8. Documentation. Before beginning fabrication, provide a completed Material Statement Form 1818 (a.k.a. D-9-USA-1) with supporting documentation (such as mill test reports (MTRs)) that the producing mill issues and qualified personnel verifies. Ensure the documentation legibly reflects all information the applicable ASTM specifications require. Supply documents electronically to the Department.

Provide a copy of the shipping or storage invoice, as material is shipped or placed in approved storage, that reflects:

- member piece mark identification and calculated weight per piece from the contract drawings,
- number of pieces shipped or in storage,
- total calculated weight for each invoice per bid item, and
- the unique identification number of the shipping or storage invoice.

The inspector's acceptance of material or finished members will not prohibit subsequent rejection if the material or members are found to be damaged or defective. Replace rejected material promptly.

3.1.9. Material Identification. Assembly-mark individual pieces and issue cutting instructions to the shop using a system that will maintain identity of the original piece.

Identify structural steel by standard and grade of steel. Also differentiate between material toughness requirements (CVN, fracture-critical) as well as any other special physical requirements. In addition, identify structural steel for primary members by mill identification numbers (heat numbers). Use an approved identification system. Use either paint or low-stress stencils to make identification markings on the metal. Mark the material as soon as it enters the shop and carry the markings on all pieces through final fabrication. Transfer the markings before cutting steel for primary members of bridge structures into smaller pieces. Loss of identification marking on any piece, with no other positive identification, or loss of heat number identification on any primary member piece will render the piece unacceptable for use. Unidentifiable material may be approved for use after testing to establish acceptability to the satisfaction of the Engineer. Have an approved testing facility perform testing and a licensed professional engineer sign and seal the results.

3.2. Welding.

3.2.1. Details.

3.2.1.1. Rolled Edges. Trim plates with rolled edges used for webs by thermal cutting.

3.2.1.2. Weld Tabs. Use weld tabs at least 2 in. long for manual and semi-automatic processes, at least 3 in. long for automatic processes, and in all cases at least as long as the thickness of the material being welded. Use longer weld tabs as required for satisfactory work.

3.2.1.3. Weld Termination. Terminate fillet welds approximately 1/4 in. from the end of the attachment except for galvanized structures and flange-to-web welds, for which the fillet weld must run the full length of the attachment, unless otherwise shown on the plans.

3.2.1.4. No-Paint Areas at Field-Welded Connections. Keep surfaces within 4 in. of groove welds or within 2 in. of fillet welds free from shop paint.

3.2.1.5. Galvanized Assemblies. Completely seal all edges of tightly contacting surfaces by welding before galvanizing.

3.2.1.6. Submerged-Arc Welding (SAW). Do not use hand-held semiautomatic SAW for welding bridge members unless altered to provide automatic guidance or otherwise approved.

3.2.1.7. Tubular Stiffeners for Bridge Members. Weld in accordance with AWS D1.5, using WPSs qualified based on tests on ASTM A709 Gr. 50W or Gr. 50 steel for non-weathering applications and ASTM A709 Gr. 50W steel for weathering applications.

3.2.1.8. Non-Bridge Member Weathering Steel Welds. Provide weld metal with atmospheric corrosion resistance and coloring characteristics similar to that of the base metal for weathering steel structures fabricated per AWS D1.1.

3.2.2. Shop Splices.

3.2.2.1. Shop Splice Locations. Keep at least 6 in. between shop splices and stiffeners or cross-frames. Obtain approval for shop splices added after shop drawings are approved.

3.2.2.2. Grinding Splice Welds. Grind shop groove welds in flange plates smooth and flush with the base metal on all surfaces whether the joined parts are of equal or unequal thickness. Grind so the finished grinding marks run in the direction of stress, and keep the metal below the blue brittle range (below 350°F). Groove welds in web plates, except at locations of intersecting welds, need not be ground unless shown on the plans except as required to meet AWS welding code requirements.

3.2.3. Joint Restraint. Never restrain a joint on both sides when welding.

3.2.4. Stiffener Installation.

3.2.4.1. Flange Tilt. Members must meet combined tilt and warpage tolerances before the installation of stiffeners. Cut stiffeners to fit acceptable flange tilt and cupping. Minor jacking or hammering that does not permanently deform the material will be permitted.

3.2.4.2. Stiffeners Near Field Splices. Tack weld intermediate stiffeners within 12 in. of a welded field splice point in the shop. Weld the stiffeners in the field in accordance with Item 448, “Structural Field Welding,” after the splice is made.

3.2.5. Nondestructive Testing (NDT). Perform magnetic particle testing (MT), radiographic testing (RT), or ultrasonic testing (UT) at the Contractor’s expense as specified in D1.5 for bridge structures. The Engineer will periodically witness, examine, verify, and interpret NDT. Additional welds may be designated for NDT on the plans. Retest repaired groove welds per the applicable AWS code after repairs are made and have cooled to ambient temperature. Complete NDT and repairs before assembly of parts into a member, but after any heat-correction of weld distortion.

3.2.5.1. Radiographic Testing. Radiographs must have a density of at least 2.5 and no more than 3.5, as a radiographer confirms. The density in any single radiograph showing a continuous area of constant thickness must not vary in this area by more than 0.5. Use only ASTM System Class I radiographic film as described in ASTM E1815. Use low-stress stencils to make radiograph location identification marks on the steel.

3.2.5.2. Ultrasonic Testing. Have UT equipment calibrated yearly by an authorized representative of the equipment manufacturer or by an approved testing laboratory.

3.2.5.3. Magnetic Particle Testing. Use half-wave rectified DC when using the yoke method unless otherwise approved. Welds may be further evaluated with prod method for detecting centerline cracking.

3.2.6. Testing of Galvanized Weldments. If problems develop during galvanizing of welded material, the Engineer may require a test of the compatibility of the combined galvanizing and welding procedures in accordance with this Section and may require modification of one or both of the galvanizing and welding procedures.

Prepare a test specimen with a minimum length of 12 in. using the same base material, with the same joint configuration, and using the welding procedure proposed for production work if testing is required. Clean and

galvanize this test specimen using the same conditions and procedure that will be applied to the production galvanizing.

Examine the test specimen after galvanizing. There must be no evidence of excessive buildup of zinc coating over the weld area. Excessive zinc coating buildup will require modification of the galvanizing procedure.

Remove the zinc from the weld area of the test specimen and visually examine the surface. There must be no evidence of loss of weld metal or any deterioration of the base metal due to the galvanizing or welding procedure. Modify the galvanizing or welding procedure as required if there is evidence of deterioration or loss of weld metal, and run a satisfactory retest on the modified procedures before production work. Report procedures and results on the galvanized weldment worksheet provided by the Department.

3.3. Bolt Holes. Detail holes on shop drawings 1/16 in. larger in diameter than the nominal bolt size shown on the plans unless another hole size is shown on the plans.

Thoroughly clean the contact surfaces of connection parts in accordance with Item 447, “Structural Bolting,” before assembling them for hole fabrication. Make holes in primary members full-size (by reaming from a subsize hole, drilling full-size, or punching full-size where permissible) only in assembly unless otherwise approved.

Ream and drill with twist drills guided by mechanical means unless otherwise approved. If subpunching holes, punch them at least 3/16 in. smaller than the nominal bolt size. Submit the proposed procedures for approval to accomplish the work from initial drilling or punching through check assembly when numerically controlled (N/C) equipment is used. Use thermal cutting for holes only with permission of the Engineer. Permission for thermal cutting is not required for making slotted holes, when slotted holes are shown on the plans, by drilling or punching 2 holes and then thermally cutting the straight portion between them. Perform all thermal cutting in accordance with Section 441.3.5.1., “Thermal Cutting.”

Slightly conical holes that naturally result from punching operations are acceptable provided they do not exceed the tolerances of S2.1. The tolerance for anchor bolt hole diameter for bridge bearing assemblies is +1/8 in., −0.

3.4. Dimensional Tolerances. Meet tolerances of the applicable AWS specifications and S2.1 except as modified in this Section.

3.4.1. Rolled Sections. Use ASTM A6 mill tolerances for rolled sections, except D1.5 camber tolerances apply to rolled sections with a specified camber.

3.4.2. Flange Straightness. Ensure flanges of completed girders are free of kinks, short bends, and waviness that depart from straightness or the specified camber by more than 1/8 in. in any 10 ft. along the flange. Rolled material must meet this straightness requirement before being laid out or worked. Plates must meet this requirement before assembly into a member. Inspect the surface of the metal for evidence of fracture after straightening a bend or buckle. The Engineer may require nondestructive testing.

3.4.3. Alignment of Deep Webs in Welded Field Connections. For girders 48 in. deep or deeper, the webs may be slightly restrained while checking compliance with tolerances of S2.1 for lateral alignment at field-welded connections. In the unrestrained condition, webs 48 in. deep or deeper must meet the tolerances of Table 2. Girders under 48 in. deep must meet the alignment tolerances of S2.1.

Table 2
Web Alignment Tolerances for Deep Girders

| Web Depth (in.) | Maximum Web Misalignment (in.) |
|---|---|
| 48 | 1/16 |
| 60 | 1/8 |
| 72 | 1/4 |
| 84 | 5/16 |
| 96 | 5/16 |
| 108 | 3/8 |
| 120 | 7/16 |
| 132 | 7/16 |
| 144 | 1/2 |

3.4.4. Bearings. Correct bearing areas of shoes, beams, and girders using heat, external pressure, or both. Grind or mill only if the actual thickness of the member is not reduced by more than 1/16 in. below the required thickness.

3.4.4.1. I-Beams, Plate Girders, and Tub Girders. The plane of the bearing area of beams and girders must be perpendicular to the vertical axis of the member within 1/16 in. in any 24 in.

3.4.4.2. Closed Box Girders. Meet these tolerances:

- The plane of the bearing areas of the box girder is perpendicular to the vertical axis of the girder within 1/16 in. across any horizontal dimension of the bearing.
- The planes of the beam supports on the box girder are true to the vertical axis of the supported beams or girders to 1/16 in. in any 24 in.

In the shop, verify the plane of all bearing areas with the box placed on its bearings to field grade, using an approved process for verification.

3.4.4.3. Shoes. Meet these tolerances:

- The top bolster has the center 75% of the long dimension (transverse to the girder) true to 1/32 in., with the remainder true to 1/16 in., and is true to 1/32 in. across its entire width in the short dimension (longitudinal to the girder).
- The bottom bolster is true to 1/16 in. across its diagonals.
- For a pin and rocker type expansion shoe, the axis of rotation coincides with the central axis of the pin.
- When the shoe is completely assembled, as the top bolster travels through its full anticipated range, no point in the top bolster plane changes elevation by more than 1/16 in. and the top bolster does not change inclination by more than 1 degree, for the full possible travel.

3.4.4.4. Beam supports. Fabricate beam support planes true to the box girder bearing to 1/16 in. in the short direction and true to the vertical axis of the nesting girders to 1/16 in.

3.4.5. End Connection Angles. For floor beams and girders with end connection angles, the tolerance for the length back to back of connection angles is ±1/32 in. Do not reduce the finished thickness of the angles below that shown on the shop drawings if end connections are faced.

3.5. Other Fabrication Processes.

3.5.1. Thermal Cutting. Use a mechanical guide to obtain a true profile. Hand-cut only where approved. Hand-cutting of radii for beam copes, weld access holes, and width transitions is permitted if acceptable profile and finish are produced by grinding. Provide a surface finish on thermal-cut surfaces, including holes, in accordance with D1.5 requirements for base metal preparation. Obtain approval before using other cutting processes.

3.5.2. Oxygen-Gouging. Do not oxygen-gouge quenched and tempered (Q&T), normalized, or thermo-mechanically controlled processed (TMCP) steel.

3.5.3. Annealing and Normalizing. Complete all annealing or normalizing (as defined in ASTM A941) before finished machining, boring, and straightening. Maintain the temperature uniformly throughout the furnace during heating and cooling so the range of temperatures at all points on the member is no more than 100°F.

3.5.4. Machining. Machine the surfaces of expansion bearings so the travel direction of the tool is in the direction of expansion.

3.5.5. Camber. Complete cambering in accordance with S2.1 before any heat-curving.

3.5.6. Heat Curving. Heat-curve in accordance with S2.1. The methods in the AASHTO bridge construction specifications are recommended. Attach cover plates to rolled beams before heat-curving only if the total thickness of one flange and cover plate is less than 2-1/2 in. and the radius of curvature is greater than 1,000 ft. Attach cover plates for other rolled beams only after heat-curving is completed. Locate and attach connection plates, diaphragm stiffeners, and bearing stiffeners after curving, unless girder shrinkage is accounted for.

3.5.7. Bending of Quenched and Tempered Steels. The cold-bending radius limitations for HPS 70W in S2.1 apply to all Q&T steels.

3.6. Nonconformance Reports (NCRs). Submit an NCR to the Engineer for approval when the requirements of this Item are not met. Submit NCRs in accordance with the Construction Division's NCR guidelines document. Have readily available access to the services of a licensed professional engineer experienced in steel structures design and fabrication. This licensed professional engineer may be responsible for reviewing potentially structurally deficient members in accordance with the NCR guidelines document. Receive Department approval before beginning repairs. Perform all repair work in strict compliance with the approved NCR and repair procedure.

3.7. Shop Assembly.

3.7.1. General Shop Assembly. Shop-assemble field connections of primary members of trusses, arches, continuous beam spans, bents, towers (each face), plate girders, field connections of floor beams and stringers (including for railroad structures), field-bolted diaphragms for curved plate girders and railroad underpasses, and rigid frames. Field-bolted cross-frames and rolled-section diaphragms do not require shop assembly. Complete fabrication, welding (except for shear studs), and field splice preparation before members are removed from shop assembly. Obtain approval for any deviation from this procedure. The Contractor is responsible for accurate geometry.

Use a method and details of preassembly consistent with the erection procedure shown on the erection plans and camber diagrams. The sequence of assembly may start from any location in the structure and proceed in one or both directions. An approved method of sequential geometry control is required unless the full length of the structure is assembled.

Verify by shop assembly the fit of all bolted and welded field connections between bent cap girders and plate girders or between plate girders and floor beams.

Do not measure horizontal curvature and vertical camber for final acceptance until all welding and heating operations are completed and the steel has cooled to a uniform temperature. Check horizontal curvature and vertical camber in a no-load condition.

3.7.2. Bolted Field Connections. Each shop assembly, including camber, alignment, accuracy of holes, and fit of milled joints, must be approved before the assembly is dismantled.

Assemble with milled ends of compression members in full bearing. Assemble non-bearing connections to the specified gap. Ream all subsize holes to the specified size while the connections are assembled, or drill full size while the connections are assembled. Notify the Engineer before shipping if fill plates or shims are added. Adding or increasing the thickness of shims or fill plates in bearing connections requires approval. Use drift pins and snug-tight bolts during the drilling process to ensure all planes of the connection (webs and flanges) can be assembled simultaneously. Do not use tack welds to secure plates while drilling.

Secure parts not completely bolted in the shop with temporary bolts to prevent damage in shipment and handling. Never use tack welds in place of temporary bolts.

Match-mark connecting parts in field connections using low-stress stencils in accordance with the diagram in the erection drawings.

3.7.3. Welded Field Connections. Mill or grind bevels for groove welds. Do not cut into the web when cutting the flange bevel adjacent to the web. End preparation, backing, and tolerances for girder splices must be in accordance with Item 448, "Structural Field Welding." Details for all other field-welds must conform to the applicable AWS code unless otherwise shown on the plans.

In the shop, prepare ends of beams or girders to be field-welded taking into account their relative positions in the finished structure due to grade, camber, and curvature. Completely shop-assemble and check each splice. Match-mark the splice while it is assembled with low-stress stencils in accordance with the diagram in the erection drawings.

3.8. Finish and Painting.

3.8.1. Shop Painting. Perform shop painting as required in DMS-8104, "Paint, Shop Application for Steel Bridge Members." Grind corners on new steel items to be painted (except for the coatings on box and tub girder interiors) that are sharp or form essentially 90° angles to an approximately 1/16 in. flat surface before blast cleaning. (A corner is the intersection of 2 plane faces.) This requirement does not apply to punched or drilled holes. Do not omit shop paint to preserve original markings.

Ensure painted faying surfaces meet the required slip and creep coefficients for bolted connections as outlined in DMS-8104, "Paint, Shop Application for Steel Bridge Members."

Use a Class A slip (minimum slip coefficient of 0.33) if no slip coefficient or corresponding surface condition is specified Perform all required testing at no expense to the Department.

Surface preparation and painting the interiors of Tub Girders and Closed Boxes is in accordance with DMS-8104, "Paint, Shop Application for Steel Bridge Members."

3.8.2. Weathering Steel. Provide an SSPC-SP 6 blast in the shop to all fascia surfaces of unpainted weathering steel beams. Fascia surfaces include:

- exterior sides of outermost webs and undersides of bottom flanges of plate girders and rolled beams,
- all outer surfaces of tub girders and box girders,
- all surfaces of truss members,
- webs and undersides of bottom flanges of plate diaphragms,
- bottom surfaces of floor beams, and
- any other surfaces designated as "fascia" on the plans.

Do not mark fascia surfaces. Use one of the following methods as soon as possible to remove any markings or any other foreign material that adheres to the steel during fabrication and could inhibit the formation of oxide film:

- SSPC-SP 1, "Solvent Cleaning"
- SSPC-SP 2, "Hand Tool Cleaning"
- SSPC-SP 3, "Power Tool Cleaning"

- SSPC-SP 7, “Brush-off Blast Cleaning”

Do not use acids to remove stains or scales. Feather out touched-up areas over several feet.

3.8.3. Machined Surfaces. Clean and coat machine-finished surfaces that are in sliding contact, particularly pins and pinholes, with a non-drying, water-repellent grease-type material containing rust-inhibitive compounds. Ensure the coating material contains no ingredients that might damage the steel. Protect machined surfaces from abrasive blasting.

3.9. Handling and Storage of Materials. Prevent damage when storing or handling girders or other materials. Remove or repair material damaged by handling devices or improper storage by acceptable means in accordance with ASTM A6 and the applicable AWS code.

Place stored materials on skids or acceptable dunnage above the ground. Keep materials clean. Shore girders and beams to keep them upright and free of standing water. Place support skids close enough to prevent excessive deflection in long members such as columns. Do not stack completed girders or beams at the jobsite.

Protect structural steel from salt water or other corrosive environments during storage and transit.

3.10. Marking and Shipping. Mark all structural members in accordance with the erection drawings. If a surface is painted, make the marks over the paint. Do not use impact-applied stencils to mark painted surfaces.

Mark the weight directly on all members weighing more than 3 tons.

Keep material clean and free from injury during loading, transportation, unloading, and storage. Pack bolts of each length and diameter, and loose nuts or washers of each size, separately and ship them in boxes, crates, kegs, or barrels. Plainly mark a list and description of the contents on the outside of each package.

3.11. Field Erection. Do not lift and place any steel member, including girders and diaphragms, over an open highway or other open travel way unless otherwise approved. Do not allow traffic to travel under erected members until sufficiently stable as shown on approved erection drawings.

3.11.1. Pre-Erection Conference. Schedule and attend a pre-erection conference with the Engineer at least 7 days before commencing steel erection operations. Do not install falsework or perform any erection operations before the meeting.

3.11.2. Methods and Equipment. Do not tack-weld parts instead of using erection bolts. Do not tack-weld parts to hold them in place for bolting. Provide falsework, tools, machinery, and appliances, including drift pins and erection bolts. Provide enough drift pins, 1/32 in. larger than the connection bolts, to fill at least 1/4 of the bolt holes for primary connections. Use erection bolts of the same diameter as the connection bolts.

Securely tie, brace, or shore steel beams or girders immediately after erection as shown on the erection drawings. Maintain bracing or shoring until the diaphragms are in place and as specified in the erection drawings. Protect railroad, roadway, and marine traffic underneath previously erected girders or beams from falling objects associated with other construction activities.

Only welders certified or working directly under the supervision of a foreman certified in accordance with Item 448, “Structural Field Welding,” may handle torches when applying heat to permanent structural steel members.

3.11.3. Falsework. Construct falsework in accordance with the erection plan. Construct foundations for shore towers as shown on erection drawings. Do not use timber mats with deteriorated timbers or soil to construct shore tower foundations. Notify the Engineer of completed falsework to obtain approval before opening roadway to traffic or starting girder erection activities. Ensure falsework is protected from potential vehicle impact.

Inspect and maintain falsework daily. Use screw jacks or other approved methods to control vertical adjustment of falsework to minimize the use of shims.

3.11.4. Handling and Assembly. Accurately assemble all parts as shown on the plans and the approved shop drawings. Verify match-marks. Handle parts carefully to prevent bending or other damage. Do not hammer if doing so damages or distorts members. Do not weld any member for transportation or erection unless noted on the plans or approved by the Engineer.

3.11.4.1. Welded Connections. Weld flange splices to 50% of their thickness and meet the minimum erection bracing and support requirements before releasing the erection cranes, as shown on the plans and on the approved erection plans. Field-weld in accordance with Item 448, "Structural Field Welding."

3.11.4.2. Bolted Connections. Before releasing the erection cranes:

- install 50% of the bolts in the top and bottom flanges and the web with all nuts finger-tight,
- meet the minimum erection bracing and support requirements shown on the plans and on the approved erection plans, and
- install top lateral bracing across the connection for tub girders, and fully tension the bolts connecting the bracing to the top flanges.

Install high-strength bolts, including erection bolts, in accordance with Item 447, "Structural Bolting." Clean bearing and faying surfaces for bolted connections in accordance with Item 447, "Structural Bolting." Clean the areas of the outside ply under washers, nuts, and bolt heads before bolt installation. Ensure the required faying surface condition is present at the time of bolting.

3.11.5. Misfits. Correct minor misfits. Ream no more than 10% of the holes in a plate connection (flange or web), and ensure no single hole is more than 1/8 in. larger than the nominal bolt diameter. Submit proposed correction methods for members with defects that exceed these limits or prevent the proper assembly of parts. Straighten structural members in accordance with S2.1. Make all corrections in the presence of the Engineer at no expense to the Department. Do not remove and reweld gusset plates without approval.

3.11.6. Bearing and Anchorage Devices. Place all bearing devices such as elastomeric pads, castings, bearing plates, or shoes on properly finished bearing areas with full and even bearing on the concrete. Place metallic bearing devices on 1/4 in.-thick preformed fabric pads manufactured in accordance with DMS-6160, "Water Stops, Nylon-Reinforced Neoprene Sheet, and Elastomeric Pads," to the dimensions shown on the plans. Provide holes in the pad that are no more than 1/4 in. larger than the bolt diameter.

Build the concrete bearing area up to the correct elevation once it has been placed below grade using mortar that meets Item 420, "Concrete Substructures," and provide adequate curing. Use only mortar for build-ups between 1/8 in. and 3/8 in. thick. Use galvanized steel shims or other approved shim materials in conjunction with mortar if the bearing area must be raised more than 3/8 in.

Provide at least 75% contact of flange to shoe with no separation greater than 1/32 in. for beams and girders. Make corrections using heat or pressure in accordance with S2.1, or with galvanized shims. Correct small irregularities by grinding.

Provide at least 85% contact between the rocker plate and the base plate. Adjust the location of slotted holes in expansion bearings for the prevailing temperature. Adjust the nuts on the anchor bolts at the expansion ends of spans to permit free movement of the span. Provide lock nuts or burr the threads.

Remove all foreign matter from sliding or machine-finished surfaces before placing them in the structure.

Restore distorted bearing pads or expansion bearings to an equivalent 70°F position after completion of all welded or bolted splices, using an approved method of relieving the load on the bearing devices.

3.11.7. Erecting Forms. Do not erect forms until all welding or bolting is complete and the unit is positioned and properly set on the bearings unless otherwise noted on the plans.

3.11.8. **Field Finish**. Paint in accordance with Item 446, "Field Cleaning and Painting Steel." Restore weathering steel that will remain unpainted to a uniform appearance by solvent cleaning, hand cleaning, power brush, or blast cleaning after all welding and slab concrete placement has been completed. Remove from all unpainted weathering steel fascia surfaces (see Section 441.3.8.2., "Weathering Steel,") any foreign material, including markings, that adheres to the steel and could inhibit formation of oxide film as soon as possible. Feather out touched-up areas over several feet. Do not use acids to remove stains or scales.

## 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 442
# Metal for Structures

## 1. DESCRIPTION

Provide structural steel, high-strength bolts, forgings, steel castings, iron castings, wrought iron, steel pipe and tubing, aluminum castings and tubing, or other metals used in structures, except reinforcing steel and metal culvert pipe.

## 2. MATERIALS

Furnish mill test reports (MTRs), supplemental test documentation, and certifications required by this and other pertinent Items.

2.1. Structural Steel. The Engineer may sample and test steel in accordance with ASTM A370.

2.1.1. Bridge Structures. Provide the grade of ASTM A709 steel shown on the plans. Grade 50W, 50S, or HPS 50W may be substituted for Grade 50 at no additional cost to the Department. Use Zone 1 if no AASHTO temperature zone is shown on the plans.

2.1.2. Non-Bridge Structures.

2.1.2.1. Steel Classifications. Provide the types and grades of steel listed in this Section unless otherwise shown on the plans.

2.1.2.1.1. Carbon Steel. Meet ASTM A36.

2.1.2.1.2. Low-Alloy Steel. Meet the requirements of one of the following standards:

- ASTM A529 Grade 50;
- ASTM A572 Grade 50 or 55;
- ASTM A588;
- ASTM A709 Grade 50, 50S, 50W, or HPS 50W; or
- ASTM A992.

Specify ASTM A6 supplemental requirement S18, "Maximum Tensile Strength," for material used for sign, signal, and luminaire supports.

2.1.2.2. Impact Testing. Tension members and components of the following structure types, if more than 1/2 in. thick. Other members designated on the plans must meet the Charpy V-notch (CVN) requirements of Table 1:

- base plates for roadway illumination assemblies, traffic signal pole assemblies, high mast illumination poles, camera poles, and overhead sign supports;
- pole mounting plates, arm mounting plates, and clamp-on plates for traffic signal pole assemblies;
- arm stiffeners, pole gussets, and stiffeners for traffic signal pole long mast arm assemblies (50 ft. to 65 ft.);
- pole shafts, ground sleeves, and handhole frames for high mast illumination poles;
- W-columns, tower pipes, multiple-sided shafts, tower pipe and multiple-sided shaft connection plates, chord angles, chord splice plates or angles, and truss bearing angles for truss type overhead sign supports; and

- pipe posts, pipe arms, post and arm flange plates, and handhole frames for monotube overhead sign supports.

Table 1
CVN Requirements for Non-Bridge Steel

| Material | Thickness | Minimum CVN Toughness |
|---|---|---|
| ASTM A36, A53, A242, A500, A501, A709 Gr. 36, any other steel with minimum specified yield point below 40 ksi | up to 4" | 15 ft.-lb. at 70°F |
| ASTM A572,[1] A588,[1] A633,[1] any other steel with minimum specified yield point between 40 and 65 ksi, inclusive | up to 2" | 15 ft.-lb. at 70°F |
| | over 2" to 4", mechanically fastened | 15 ft.-lb. at 70°F |
| | over 2" to 4", welded | 20 ft.-lb. at 70°F |
| Any steel with minimum specified yield point over 65 ksi and under 90 ksi[2] | up to 2-1/2" | 20 ft.-lb. at 50°F |
| | over 2-1/2" to 4", mechanically fastened | 20 ft.-lb. at 50°F |
| | over 2-1/2" to 4", welded | 25 ft.-lb. at 50°F |

1. Reduce the testing temperature by 15°F for each 10-ksi increment or fraction thereof above 65 ksi if the yield point of the material given on the MTR exceeds 65 ksi.
2. Reduce the testing temperature by 15°F for each 10-ksi increment or fraction thereof above 85 ksi if the yield point of the material given on the MTR exceeds 85 ksi.

Use the (H) frequency of testing for material with minimum specified yield point up to 50 ksi. Use the (P) frequency of testing for material with minimum specified yield point over 50 ksi. Ensure steel is sampled and tested in accordance with ASTM A673.

2.1.3. Other Components.

2.1.3.1. Miscellaneous Bridge Components. Provide steel that meets ASTM A36, A709 Grade 36, or A500 Grade B for members such as steel bearing components not bid under other Items, steel diaphragms for use with concrete bridges, and armor and finger joints, unless otherwise shown on the plans.

2.1.3.2. Shear Connectors and Anchors. Provide cold-drawn bars for stud shear connectors, slab anchors, and anchors on armor and finger joints that meet the requirements of ASTM A108, Grade 1010, 1015, 1018, or 1020, either semi-killed or killed, and have the tensile properties given in Table 2 after drawing or finishing. Determine tensile properties in accordance with ASTM A370.

Table 2
Minimum Tensile Properties for Bar Stock

| | |
|---|---|
| Tensile strength | 60 ksi |
| Yield strength | 50 ksi |
| Elongation | 20% (2") |
| Reduction of area | 50% |

Provide certification from the manufacturer that the studs or anchors as delivered have the required material properties.

2.1.3.3. Fasteners. Provide high-strength bolts that meet ASTM A325 or A490 as shown on the plans. The Department may sample high-strength bolts, nuts, and washers for structural connections in accordance with Tex-719-I.

Follow the requirements of Item 447, “Structural Bolting,” for tests, test reports, and supplemental requirements for high-strength bolts, nuts, and washers.

Use bolts that meet ASTM A307 and nuts that meet ASTM A563 when ASTM A325 or A490 bolts are not shown on the plans.

2.1.3.4. Slip-Resistant Deck Plates. Furnish steel for deck plates that meets ASTM A786 and one of A242, A588, or A709 Gr. 50W. State the type and trade name of material to be used on the shop drawings.

2.1.3.5. **Rail Posts**. Provide material for rail posts that meets ASTM A36 or ASTM A709 Grade 36 unless otherwise shown on the plans.

2.2. **Steel Forgings**. Provide steel forgings for pins, rollers, trunnions, or other forged parts that meet ASTM A668, Class C, D, F, or G, as shown on the plans. For pins 4 in. or smaller in diameter for non-railroad structures, material that meets ASTM A108, Grades 1016 to 1030, with a minimum yield strength of 36 ksi, may be used instead.

2.3. **Steel Castings**. Provide steel castings that meet ASTM A27, Grade 70-36.

2.4. **Iron Castings**. Provide iron castings that are true to pattern in form and dimensions; free from pouring faults, sponginess, cracks, blow holes, and other defects in positions affecting their strength and value for the service intended; and meet the standards shown in Table 3.

Table 3
Standards for Iron Castings

| Casting Material | ASTM Standard | Grade or Class |
|---|---|---|
| Gray iron | A48 | 35B |
| Malleable iron | A47 | 32510 |
| Ductile iron | A536 | 70-50-05 |

2.5. **Steel Tubing**. Provide steel tubing that meets ASTM A500, Grade B unless otherwise shown on the plans. Tubing that meets API Standard 5L, Grade X52 may be used if produced by a mill listed in the standard API specifications as authorized to produce pipe with the API monogram. Hydrostatic tests are not required for API 5L steel, and instead of an MTR, the manufacturer may furnish a certificate for each lot or shipment certifying the tubing meets the requirements of this Section.

2.6. **Pipe Rail**. "Pipe" includes special extruded and bent shapes. Provide pipe that is rolled, extruded, or cold-pressed from a round pipe or flat plate, and of the section shown on the plans.

Ensure the design of the cold press and dies results in a pipe of uniform section-free from die marks. Cut the pipe to the lengths required once it has been formed to the required section. Make the end cuts and notches at the angles to the axis of the pipe required to produce vertical end faces and plumb posts when required by the plans. Provide a neat and workmanlike finish when cutting and notching pipe.

2.7. **Aluminum**. Provide aluminum materials that meet the standards shown in Table 4 unless otherwise shown on the plans.

Table 4
Aluminum Standards

| Material | ASTM Standard | Alloy-Temper |
|---|---|---|
| Castings | B108 | A444.0-T4 |
| Extrusions | B221 | 6061-T6 |
| Sheet or plate | B209 | 6061-T6 |

When testing is required, cut test specimens from castings from the lower 14 in. of the tension flange, but not at the junction of the rib or base. Flatten the curved surfaces before machining. Provide standard test specimens in conformance with ASTM E8.

## 3. CONSTRUCTION

3.1. **Fabrication, Erection, and Painting**. Fabricate, weld, and erect structural metal in accordance with Item 441, "Steel Structures," Item 447, "Structural Bolting," Item 448, "Structural Field Welding," and the applicable AWS welding code. Paint in accordance with Item 446, "Field Cleaning and Painting Steel." Aluminum or galvanized steel members do not require painting unless otherwise shown on the plans.

3.2. **Galvanizing**. Galvanize fabricated steel items, steel castings, bolts, nuts, screws, washers, and other miscellaneous hardware in accordance with Item 445, "Galvanizing." Galvanizing is not required unless specified.

## 4. MEASUREMENT

This Item will be measured by the pound of structural metal furnished and placed in a complete structure not including the weight of erection bolts, paint, or weld metal.

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.

The maximum percent variance from the plans quantity will be as given in Table 5.

Table 5
Percent Variance

| Quantity | Variance |
|---|---|
| Over 1,000,000 lb. | 1/2% |
| 100,000 through 1,000,000 lb. | 1% |
| Under 100,000 lb. | 1-1/2% |

If the requests for increases in sizes or weights of members are approved, measurement will be made on the sizes or weights shown on the plans.

Castings, bearing plates, anchor bolts, drains, deck plates, armor and finger joints, and other metal for which no separate measurement is specified will be included in the total quantity of structural steel.

The weights of rolled materials (such as structural shapes and plate) will be computed on the basis of nominal weights and dimensions using measurements shown on the plans. Deductions will not be made for material that is removed for copes, clips, planing, or weld preparation. The weight of castings will be computed from the dimensions shown on the approved shop drawings. Shoes will be measured by the weights shown on the plans.

Weight of high-strength fasteners will be based on Table 6. Weight of other metal will be based on Table 7.

Splices will be measured as follows:

- No additional weight will be allowed for weld metal in a welded splice.
- Where a bolted splice is permitted as an alternate for a welded splice, measurement will be made on the basis of a welded splice.
- Where a bolted splice is required, the weight of the splice material, bolt heads, washers, and nuts will be measured with no deduction for holes.

Table 6
Pay Weight for High-Strength Fasteners, Pounds per Hundred Units

| Diameter | Item | | |
|---|---|---|---|
| | Bolt heads | Nuts | Washers |
| 3/4" | 15 | 19 | 4.8 |
| 7/8" | 23 | 30 | 7.0 |
| 1" | 32 | 43 | 9.4 |
| 1-1/8" | 45 | 59 | 11 |
| 1-1/4" | 64 | 79 | 14 |

Table 7
Pay Weight for Metals

| Material | Weight (lb./cu. in.) |
|---|---|
| Steel | 0.2836 |
| Cast iron | 0.2604 |
| Wrought iron | 0.2777 |

## 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 "Structural Steel" of the type (Rolled Beam, Plate Girder, Tub Girder, Box Girder, Railroad Through-Girder, Railroad Deck-Girder, Miscellaneous Bridge, Miscellaneous Non-Bridge) specified. This price is full compensation for materials, fabrication, transportation, erection, paint, painting, galvanizing, equipment, tools, labor, and incidentals.

# Item 445
# Galvanizing

## 1. DESCRIPTION

Galvanize or repair galvanizing on metal items.

## 2. MATERIALS

Provide galvanized metal items that meet the standards in Table 1.

Table 1
Galvanizing Standards

| Item | Standard |
|---|---|
| Fabricated items, rolled, pressed, or forged steel shapes, plates, pipes, tubular items, and bars | ASTM A123 |
| Steel or iron castings | ASTM A153, Class A |
| Bolts, nuts, screws, washers, and other miscellaneous hardware | ASTM A153, Class C or D or ASTM B695, Class 50 |
| Miscellaneous fasteners | ASTM B633, Class Fe/Zn 8 |
| Rail elements for metal beam guard fence or bridge railing | AASHTO M 180 |
| Permanent metal deck forms, supporting angles, and incidental items | ASTM A653, Coating Designation G165 |

## 3. CONSTRUCTION

3.1. General. Provide for proper filling, venting, and draining during cleaning and galvanizing if fabricated members or assemblies are required to be hot-dip galvanized. Provide drain holes or slots as required, except where prohibited by the plans. Provide a surface finish on the thermal-cut drain holes or slots in accordance with AWS D1.1 requirements for base metal preparation. Drain to the small end of tapered sections that are assembled using slip-joint splices. Ensure cleaning and galvanizing does not produce hydrogen embrittlement.

Remove weld flux, weld slag, and any other weld residue or impurities before galvanizing. Before galvanizing material 1/4 in. or greater in thickness:

- remove all sharp burrs and
- chamfer to approximately 1/16 in. all edges.

3.2. Painting Galvanized Materials. Provide a paint system if painting is specified on galvanized materials in accordance with DMS-8102 “Paint Systems for Galvanized Steel.” Follow all manufacturer instructions for surface preparation and application including the following:

3.2.1. Surface Preparation. Do not water-quench or chromate-quench galvanized surfaces to be painted. Prepare the surface in accordance with ASTM D6386. Apply coating within 12 hr. of cleaning. Re-clean the surface if more than 12 hr. elapse before initial painting.

3.2.2. Coating Application. Ensure the coating is smooth, even, continuous, and free of drips, runs, sags, holidays, wrinkles, or other coating defects. Ensure the coating has a uniform appearance within all portions of the painted piece and all related pieces and components of a project. Ensure all repairs are smooth, even, and visually match the remainder of the coated piece by use of feathering and other appropriate techniques to avoid sharp transitions.

3.3 Galvanizing Weldments. If problems develop during galvanizing of welded material, The Engineer may require a compatibility test of the combined galvanizing and welding procedures in accordance with Section 441.3.2.6., "Testing of Galvanized Weldments," and may require modification of one or both of the galvanizing and welding procedures.

3.4. Workmanship.

3.4.1. Coverage. Bare spots no more than 1/8 in. across are acceptable unless numerous. Repair larger bare spots in accordance with Section 445.3.5., "Repairs." Local runs or drips of zinc coating are acceptable unless they interfere with the intended use of the product. Carefully remove plainly visible excessive zinc accumulations.

3.4.2. Adhesion. Tap the coated area with a small hammer to test coating adhesion. The coating is acceptable if it is not brittle and does not scale or flake.

3.4.3. Appearance.

3.4.3.1. White Rust. A white powdery residue indicates moisture. Remove heavy layers of white rust that have caused the coating to pit. Light coatings may remain unless the Engineer requires chemical removal. Remove white rust from articles that will be in direct contact with soil.

3.4.3.2. Red Rust. Red rust on galvanized items indicates uncoated areas. See Section 445.3.4.1., "Coverage," for acceptance criteria.

3.4.3.3. Alligator Cracking or Spider Webbing. The composition of the base metal may cause dark lines resembling alligator skin. See Section 445.3.4.2., "Adhesion," to determine whether the coating is acceptable.

3.4.3.4. Dull Gray Coating. The composition of the base metal can cause a dull gray color. See Section 445.3.4.2., "Adhesion," to determine whether the coating is acceptable.

3.4.4. Coating Thickness. Galvanize to the thickness specified. Use Tex-728-I to determine coating thickness.

3.5. Repairs. Use zinc-based solders, sprayed zinc, or zinc-rich paints for repairs in accordance with this Section.

3.5.1. Materials.

3.5.1.1. Zinc-Based Solders. Solders used in rod form or as powders:

- zinc-tin-lead alloys with liquidus temperatures in the range of 446°F to 500°F or
- zinc-cadmium alloys with liquidus temperatures in the range of 518°F to 527°F.

3.5.1.2. Sprayed Zinc (Metallizing). Zinc coating applied by spraying with droplets of molten metal using wire, ribbon, or powder processes.

3.5.1.3. Organic Zinc-Rich Paints. Zinc-rich paints based on organic binders that meet the requirements of DMS-8103, "Galvanizing Repair Paints." The Department's MPL has a list of approved repair paints for galvanized coatings.

3.5.2. Repair Processes.

3.5.2.1. Zinc-Based Solders. Remove moisture, oil, grease, dirt, corrosion products, and welding slag or flux from surfaces to be repaired. Clean surface to white metal by wire-brushing, light grinding, or mild blasting extending into the surrounding undamaged galvanized coating. Preheat cleaned areas to at least 600°F, but not more than 750°F. Wire-brush while heating and evenly distribute a layer of zinc solder. Flush the repaired area with water or wipe with a damp cloth to remove flux residue when repair is completed.

3.5.2.2. Sprayed Zinc (Metallizing). Remove oil, grease, corrosion products, and any welding slag or flux from surfaces to be repaired, and ensure the surfaces are dry. Clean surface to white metal by wire-brushing, light grinding, or mild blasting extending into the surrounding undamaged galvanized coating. Apply coating by metal-spraying pistols fed with either zinc wire, ribbon, or powder. Provide a coating that is uniform and free
of lumps, coarse areas, or loose particles.

3.5.2.3. Organic Zinc-Rich Paints. Remove oil, grease, corrosion products, and welding slag or flux from surfaces to be repaired, and ensure the surfaces are clean and dry. Clean surface to near-white metal by wire- brushing, light grinding, or mild blasting extending into the surrounding undamaged coating to provide a smooth repair. Spray or brush-apply the paint to the prepared area in accordance with the paint manufacturer's instructions to attain the required dry-film thickness. Provide multiple passes when using spray application.

3.6. Repair Coating Thickness. Measure thickness in the repaired area using Tex-728-I after completing repair and cooling or curing. The minimum thickness required is the same as that required for the specified galvanizing. However, if the repair uses zinc-rich paints, the minimum coating thickness is 50% higher than the specified galvanizing thickness but not greater than 4.0 mils.

## 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 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 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 447
# Structural Bolting

## 1. DESCRIPTION

Furnish and install high-strength bolts for structural connections.

## 2. MATERIALS

2.1. **General**. Use the same supplier for bolts and nuts to ensure proper fit. Have the manufacturer or distributor perform rotational-capacity (R-C) tests in accordance with Tex-452-A on all bolt, nut, and washer assemblies. Test each combination of bolt production lot, nut lot, and washer lot as an assembly and assign an R-C lot number to each lot tested. Test 2 samples from each assigned R-C lot.

Furnish a manufacturer's certified test report (MCTR) or a distributor's certified test report (DCTR) for each R-C lot supplied. Include in the MCTR or DCTR:

- results of the R-C tests,
- R-C lot number,
- manufacturing location for assembly components,
- date and location of tests, and
- a statement that the materials represented by the test report conform to the specifications.

2.2. **Bolt Assemblies**. Provide bolts, nuts, and washers meeting the type, grade, and finish requirements in Table 1.

Use ASTM A325 or A490 Type 3 plain (uncoated) bolts for weathering steel as indicated and ASTM A325 Type 1 galvanized bolts for coated steel.

Provide bolts long enough for the installed bolt end to be flush with or outside the face of the nut.

Ensure galvanized nuts are lubricated with a lubricant containing a dye of a color that contrasts with the color of the galvanizing. Order ASTM A563 nuts with supplemental requirement S2 if they will be galvanized.

Table 1
ASTM Type, Finish, and Grade for Structural Bolts, Nuts, and Washers

| | ASTM Designation | Bolt Type | Bolt Finish | ASTM A563 Nut Grade and Finish | ASTM F436 Washer Type and Finish |
|---|---|---|---|---|---|
| Heavy-Hex Bolts | A325 | 1 | Galvanized | DH,[1] galvanized and lubricated | 1; galvanized |
| | A325 | 3 | Plain | C3 and DH3; plain | 3; plain |
| | A490 | 3 | Plain | DH3; plain | 3; plain |
| Tension-Control Bolts | | | Galvanized | DH,[1] galvanized and lubricated | 1; galvanized |
| | | 3 | Plain | C3 and DH3; plain | 3; plain |
| | F2280 | 3 | Plain | DH3; plain | 3; plain |

1. ASTM A194 Heavy Hex Grade 2H nuts may be substituted.

2.3. **Washer-Type Indicating Devices**. Use compressible-washer-type direct tension indicators that meet ASTM F959 if allowed. Alternative washer-type indicating devices must be approved by Engineer. Provide detailed testing, installation, and inspection requirements prepared by the manufacturer.

2.4. **Storage**. Protect all bolts and nuts from dirt and moisture at the jobsite. Remove from protected storage only those bolts and nuts anticipated to be installed during a workday. Return unused fasteners to protected

storage at the end of the day. Do not clean fasteners of lubricant present in the as-delivered condition. Perform a field R-C test at the Contractor's expense in accordance with Tex-452-A on any lot of fasteners that shows signs of rust, dirt, or loss of lubrication as directed. Apply additional lubrication and rerun the R-C test before installing bolts if the fasteners fail the R-C test. Replace any fasteners that cannot be re-lubricated to pass the field R-C test. Tension control bolts may only be re-lubricated by the manufacturer.

2.5. Sampling and Testing. Sample high-strength bolts, nuts, and washers in accordance with Tex-719-I. Perform field R-C tests as directed in accordance with Tex-452-A. Perform installation verification tests required in Section 447.4.1., "Verification Testing."

2.6. Fitup Bolts and Erection Pins. Provide heavy-hex fitup bolts of the same diameter as the connection bolts. Do not use washer-type indicating devices for fitups. Do not reuse galvanized bolts or ASTM A490 bolts that have been used as fitup bolts. Provide a sufficient number of erection or drift pins, 1/32 in. larger than the bolt diameter.

2.7. Paint Markers. Provide white or yellow paint markers for marking bolts or nuts for wrench calibration, R-C Tests, and bolt installation.

## 3. EQUIPMENT

3.1. Testing Equipment. Provide a calibrated tension-measuring device (Skidmore-Wilhelm or equivalent), calibrated torque wrench, and other accessories necessary to perform the installation verification test and the R-C test and to calibrate hydraulic or electric torque wrenches.

3.2. Wrenches. Furnish either of the following types of wrenches.

3.2.1. Air-Driven Impact Wrenches. Furnish air-driven impact wrenches, air compressors, and related accessories of sufficient capacity to properly tension high-strength bolts. Impact wrenches should be of sufficient size and capacity to be able to tension fully a bolt in less than 15 sec. Repair or replace any wrenches that are unable to apply full tension to a bolt within this time.

3.2.2. Calibrated Torque Wrenches. Furnish calibrated hydraulic or electric torque wrench and related accessories capable of properly tensioning high-strength bolts. Calibrate the wrench to stall out or cut out completely when the bolt tension reaches 1.05 times the tension specified in Table 2. Calibrate the wrench by tensioning 3 bolts of each size in a calibrated tension-measuring device (Skidmore-Wilhelm or equivalent). Mark each bolt and verify the rotation from snug-tight when calibrating the wrench as specified in Section 447.4.5.3.1., "Turn-of-the-Nut Method." Calibrate the wrench at least once each working day or as directed. Recalibrate the wrench for changes in bolt diameter; changes in bolt length greater than 2 bolt diameters; significant differences in the surface condition of the bolts, threads, nuts, or washers; or changes in the equipment or hose length.

## 4. CONSTRUCTION

4.1. Verification Testing. Have each member of the bolting crew that will perform the actual work complete an acceptable pre-installation verification test in the presence of the Engineer. Only crewmembers that have demonstrated proper workmanship via verification testing may perform production bolting work.

4.1.1. Air-Driven Impact Wrench. Perform an installation verification test on 3 complete fastener assemblies of each combination of diameter, length, grade, and lot to be installed before beginning bolting. Follow the bolt-tensioning procedures in Section 447.4.5.3., "Tension Bolts." Use a calibrated tension-measuring device (Skidmore-Wilhelm or equivalent) to verify and demonstrate that the method for estimating the snug-tight condition and controlling the turns from snug-tight develops a tension greater than 1.05 times the tension specified in Table 2. The snug-tight condition is defined as the tightness that exists when the plies of the joint are in firm contact.

4.1.2. Calibrated Torque Wrench. Calibrate the wrench before beginning bolting in accordance with Section 447.3.2.2., "Calibrated Torque Wrenches." Use the bolting crew that will perform the actual work for the calibration and calibrate the wrench in the presence of the Engineer. Follow the bolt-tensioning procedures in Section 447.4.5.3., "Tension Bolts."

4.1.3. Direct-Tension Indicator. Use a calibrated tension-measuring device for compression-type indicators to verify the gap is not less than 0.015 in. or the job inspection gap specified by the manufacturer when tension in the bolt reaches 1.05 times the tension specified in Table 2.

Follow the manufacturer's instructions for pre-installation verification testing methods and frequency for alternative washer-type indicating devices deemed acceptable.

4.2. Workmanship. The Engineer will disqualify any crewmembers not adhering to proper installation methods during production work. Disqualified crew may not perform further bolting work until they complete an additional pre-installation verification test suitable to the Engineer.

4.3. General. Ensure all material within the grip of the bolt is steel. Do not allow any compressible material such as gaskets or insulation within the grip. Ensure the slope of parts in contact with the bolt head or nut does not exceed 1:20 with respect to a plane normal to the bolt axis. Prepare all joint surfaces, including those in contact with the bolt heads, nuts, or washers, so that the surfaces are free of dirt, loose rust, loose mill scale, burrs, and other matter that would prevent solid seating of the parts.

Replace any bolts and nuts installed for shipping purposes unless the shop drawings indicate the shop-installed bolts are to be fully tensioned in the shop. Do not tension bolts that have been installed snug-tight in the shop. Remove any bolts installed snug-tight in the shop and replace them with new bolts. Inspect and prepare the joint surfaces after removing shop-installed bolts that are not fully tensioned in the shop.

Provide a hardened washer for heavy-hex and tension-control bolts under either the nut or the bolt head, whichever is turned during tensioning. Install hardened washers under both the nut and bolt head of ASTM A490 bolts when the outer plies being fastened have a yield strength less than 40 ksi.

Install an ASTM F436 washer for direct tension indicators as follows:

- under the nut when the nut is turned and the direct tension indicator is located under the bolt head;
- between the nut and the direct tension indicator when the nut is turned and the direct tension indicator is located under the nut;
- under the bolt head when the bolt head is turned and the direct tension indicator is located under the nut; and
- between the bolt head and the direct tension indicator when the bolt head is turned and the direct tension indicator is located under the bolt head.

Tension all bolts to provide the minimum bolt tension values given in Table 2.

Erect steel in conformance with Item 441, "Steel Structures." Do not tack-weld any parts to eliminate fitup bolts or to hold parts together while bolting.

Remove lubricant from bolt assemblies on painted structures after tensioning and before coating the connections.

Re-tighten the nuts or tack weld the nuts to the bolts when bolts are used to temporarily support welded diaphragms after completing the welding operations if the diaphragms are over vehicular or pedestrian traffic.

Table 2
Bolt Tension

| Nominal Bolt Size, in. | Minimum Tension (kips) | |
|---|---|---|
| | ASTM A325 Bolts | ASTM A490 Bolts |
| 1/2 | 12 | 15 |
| 5/8 | 19 | 24 |
| 3/4 | 28 | 35 |
| 7/8 | 39 | 49 |
| 1 | 51 | 64 |
| 1-1/8 | 56 | 80 |
| 1-1/4 | 71 | 102 |
| 1-3/8 | 85 | 121 |
| 1-1/2 | 103 | 148 |

4.4. Preparation of Faying Surfaces. Perform blast cleaning or painting of faying surfaces in accordance with Item 441, "Steel Structures." Provide an SSPC-SP 10 blast cleaning before shipment for weathering steel. Do not wire-brush weathering steel faying surfaces.

Roughen galvanized faying surfaces by hand wire-brushing. Do not use power wire brushes to roughen galvanized faying surfaces.

4.5. Bolt Installation. Use the following procedure for bolt installation of a complete connection:

4.5.1. Fair-Up Holes. Use a minimum number of erection or drift pins, as directed, in the holes to "fair-up" all holes.

4.5.2. Install Bolts. Install bolts in all remaining holes of the connection. Do not use excessive force, which results in damage to the threads, to install the bolts. Increase the number of erection or drift pins as necessary to align the holes if force is required to install the bolts. Do not ream the holes unless approved. Ream the holes in accordance with Section 441.3.11.5., "Misfits," if approved. Remove the erection or drift pins and install bolts in these holes. Bring the connection to a full snug-tight condition by snugging systematically from the most rigid part of the connection to the free edges. The snug-tight condition is defined as the tightness that exists when the plies of the joint are in firm, full contact and all of the bolts in the joint have been tightened sufficiently to prevent the removal of the nuts without the use of a wrench. A snug-tight condition can usually be attained by a few impacts of an impact wrench or the full effort of a worker using an ordinary spud wrench as demonstrated in the installation verification test. As necessary, re-snug previously snugged bolts that may have relaxed as a result of the subsequent snugging of adjacent bolts to ensure all bolts are simultaneously snug-tight and the connection plates are in full contact.

Fully tighten a minimum number of bolts as directed until the plies are in full contact if snugging does not bring the plies of the joint into full contact. Mark these bolts as fitup bolts. Use a non-galvanized ASTM A325 bolt of the same diameter as a fitup bolt in connections requiring the use of galvanized ASTM A325 bolts. Re-snug all remaining bolts.

Do not use washer-type indicating devices to bring the connection to a snug-tight condition. Rather, install heavy-hex bolt assemblies in a sufficient number of holes (approximately 20%) to attain firm, full contact between plies. Remove the heavy-hex bolts and install the washer-type indicating device assemblies after firm contact is established by connections in surrounding bolt holes.

4.5.3. Tension Bolts. Loosen all fitup bolts after tensioning all the other bolts in the connection. Ungalvanized ASTM A325 bolts used as fitup bolts may be reused in a connection using this type of bolt. Replace all galvanized bolts and ASTM A490 bolts used as fitup bolts. Tension these remaining untensioned bolts in accordance with this paragraph. Ensure the element not turned by the wrench (bolt head or nut) does not rotate.

4.5.3.1. Turn-of-the-Nut Method. Match-mark the nuts and the protruding bolt ends after the bolts have been brought up to snug-tight condition and before final tensioning so that actual rotation can be determined.

Tension all bolts in the connection to their final tension by the amount of rotation specified in Table 3. Start final tensioning at the center or most rigid part of the connection and progress toward the free edges.

4.5.3.2. Calibrated Wrench Method. Use a calibrated hydraulic torque wrench to tension all bolts to 1.05 times the tension given in Table 1 after they have been brought to the snug-tight condition. Calibrate the wrench in accordance with Section 447.3.2.2., "Calibrated Torque Wrenches." Start tensioning at the most rigid part of the connection and proceed to the free edges. Return the wrench to re-tension previously tensioned bolts that may have relaxed as a result of the subsequent tensioning of adjacent bolts. Place marks on the socket at one-third points so the amount of rotation can be visually determined.

4.5.3.3. Washer-Type Indicating Devices.

4.5.3.3.1. Compressible-Washer-Type Direct Tension Indicators. Ensure the direct-tension indicator arches are oriented away from the work and that they bear against the hardened bearing surface. Confirm the appropriate feeler gage is 1) accepted in at least half the spaces between protrusions before tensioning, and
2) refused entry in at least half the spaces between protrusions after tensioning.

4.5.3.3.2. Alternative Washer-Type Indicating Devices. Follow the procedures prepared by the manufacturer and approved by the Engineer. Verify proper installation after tensioning.

4.5.4. Bolt Reuse. Do not reuse ASTM A490 or galvanized ASTM A325 bolts. Ungalvanized ASTM A325 bolts may be reused one time if the threads have not been damaged. Re-tensioning previously tensioned bolts loosened by the tensioning of adjacent bolts is not considered to be reuse.

Tension all bolts in a connection within 10 days of installation. Bolts not tensioned within 10 days of installation are subject to field R-C testing. Re-lubricate or replace any installed bolts that do not have sufficient lubrication as determined by the field R-C test.

Table 3
Nut Rotation from Snug-Tight Condition[1]

| Bolt length (underside of head to end of bolt) | Disposition of Outer Face of Bolted Parts | | |
|---|---|---|---|
| | Both faces normal to bolt axis | One face normal to bolt axis and other face sloped less than 1:20 (beveled washer not used) | Both faces sloped less than 1:20 from bolt axis (beveled washer not used) |
| Up to and including 4 bolt diameters | 1/3 turn | 1/2 turn | 2/3 turn |
| Over 4 bolt diameters up to and including 8 diameters | 1/2 turn | 2/3 turn | 5/6 turn |
| Over 8 bolt diameters up to and including 12 diameters[2] | 2/3 turn | 5/6 turn | 1 turn |

1. Nut rotation is relative regardless of the element (nut or bolt) being turned. The tolerance is –0°, +30° for bolts installed by 1/2 turn or less and –0°, +45° for bolts installed by 2/3 turn or more.
2. Determine the required rotation for bolt lengths greater than 12 diameters using the installation verification test in a simulated connection of solidly fitted steel.

## 5. MEASUREMENT AND PAYMENT

Installation and testing of bolts will not be paid for directly but will be subsidiary to the pertinent Items requiring the use of high-strength bolts.

When payment for the structure associated with the bolts is made under Item 442, "Metal for Structures," bolts, nuts, and washers will be paid for in accordance with Item 442, "Metal for Structures."

# Item 448
# Structural Field Welding

## 1. DESCRIPTION

Field-weld metal members using the shielded metal arc or flux cored arc welding processes.

## 2. MATERIALS

Provide electrodes for shielded metal arc welding (SMAW) conforming to the requirements of the latest edition of ANSI/AWS A5.1 or ANSI/AWS A5.5.

Provide electrodes for flux cored arc welding (FCAW) conforming to the requirements of the latest edition of ANSI/AWS A5.20 or ANSI/AWS A5.29.

Provide electrodes and flux-electrode combinations named on the Department's MPL. To request that a product be added to this list or to renew an expired approval, the Contractor or the consumable manufacturer must submit certified reports of all tests required by the applicable AWS A5 specification according to the applicable welding code to the Construction Division. For most structural steel construction, the applicable welding code is AASHTO/AWS D1.5 or ANSI/AWS D1.1. For reinforcing steel, the applicable code is ANSI/AWS D1.4. Tests must be conducted on electrodes of the same class, size, and brand and manufactured by the same process and with the same materials as the electrodes to be furnished. Resubmit electrodes or flux-electrode combinations every 12 months for renewal.

Table 1 shows the classes of electrodes required. Use electrodes with the type of current, with the polarity, and in the positions permitted by AWS A5.1 and A5.5 for SMAW. AWS A5.20 and A5.29 specifications govern for FCAW. Obtain approval for electrode use on steel not listed in Table 1.

Table 1
Classification of Electrodes Permitted

| Type of Steel (ASTM Standards) | Electrode Specification | Process | Filler Metal Requirements |
|---|---|---|---|
| Steel piling<br><br>Armor joints<br>A500<br>A501 | AWS A5.1 or A5.5 | SMAW | E60XX<br>E70XX or<br>E70XX-X |
| | AWS A5.20 or A5.29 | FCAW | E6XTX-X<br>E7XTX-X<br>(except -2, -3,<br>-10, -GS) |
| A36<br>A572 Gr. 50<br>A588<br>A242<br>A709 Gr. 36. 50, or 50S | AWS A5.1 or A5.5 | SMAW | E7016<br>E7018<br>E7028 |
| | AWS A5.20 or A5.29 | FCAW | E7XT-1<br>E7XT-5<br>E7XT-6<br>E7XT-8 |
| Weathering steel<br><br>A588<br>A242<br>A709 Gr. 50W | AWS A5.5 | SMAW | E8018-W<br>E8016-C3<br>E8018-C3<br>E8016-C1<br>E8018-C1<br>E8016-C2<br>E8018-C2 |
| | AWS 5.29 | FCAW | E8XT1-W<br>E8XTX-Ni1<br>E8XTX-Ni2<br>E8XTX-Ni3 |
| A709 Gr. HPS 70W | AWS A5.5 | SMAW | E9018-M-H8R |
| Reinforcing steel Grade 40 | AWS A5.1 or A5.5 | SMAW | E70XX |
| Reinforcing steel Grade 60 | AWS A5.5 | SMAW | E90XX |
| Permanent metal deck forms | AWS A5.1 or A5.5 | SMAW | E6010<br>E6011<br>E6013<br>E7018 |

Note—Low-hydrogen electrodes applicable to the lower strength base metal may be used in joints involving base metals of different yield points or strengths.

E7010 and E8010 electrodes may be used when welding the root passes of beam and girder splices if the requirements of Section 448.4.3.5.1., “High-Cellulose Electrodes for Root Passes,” are met.

Use electrodes meeting the diffusible hydrogen requirements for fracture-critical welding in AASHTO/AWS D1.5 when welding fracture-critical applications.

Use gas or gas mixtures that are welding grade and have a dew point of −40°F or lower for gas-shielded FCAW. Furnish certification to the Engineer that the gas or gas mixture is suitable for the intended application and will meet the dew point requirements.

## 3. EQUIPMENT

Provide electrode drying and storing ovens that can maintain the required temperatures specified in Section 448.4.3.1., “Electrode Condition.” Each oven must have a door that is sealed and can be latched. Each oven must have a small port that may be opened briefly to insert a thermometer or the oven must be equipped with a thermometer that allows for direct reading of temperature inside the oven without opening the oven. Provide equipment able to preheat and maintain the temperature of the base metal as required and as shown on the plans. Provide approved equipment (e.g., temperature indicator sticks or infrared thermometer) for checking preheat and interpass temperatures at all times while welding is in progress.

Provide welding equipment meeting the requirements of the approved welding procedure specifications (WPS), if required, and capable of making consistent high-quality welds.

## 4. CONSTRUCTION

4.1. **Procedure Qualification**. Use the proper classification and size of electrode, arc length, voltage, and amperage for the thickness of the material, type of groove, welding positions, and other circumstances of the work.

Submit WPSs for FCAW, qualified in accordance with AASHTO/AWS D1.5 for approval before any field welding on a project.

4.2. **Welder Qualification**. Provide Department certification papers for each welder and for each welding process to be used before welding, except for miscellaneous welds described in Section 448.4.2.1.1., "Miscellaneous Welding Applications." Certification is issued by the Department as described in Section 448.4.2.2., "Certified Steel Structures Welder."

4.2.1. **Miscellaneous Welding**. A qualified welder is an experienced welder who is capable of making welds of sound quality but does not have Department certification papers. The Engineer will check the welder's ability by conducting a jobsite test in accordance with Section 448.4.2.1.2., "Miscellaneous Weld Qualification Test," before welding begins. Furnish all materials and equipment necessary for this test.

4.2.1.1. **Miscellaneous Welding Applications**. A welder certified for structural or reinforcing steel or a qualified welder may make miscellaneous welds of the following types:

- splicing reinforcing steel to extend bars in the bottom of a drilled shaft;
- attaching chairs to the reinforcing steel cage of a drilled shaft;
- armor joints and their supports;
- screed rail and form hanger supports where permitted on steel units;
- reinforcing steel to R-bars for lateral stability between prestressed beams, spirals, or bands to reinforcing bars in drilled shaft cages;
- permanent metal deck forms;
- additional steel added in railing when slip-form construction is used; and
- other similar miscellaneous members that have no load-carrying capacity in the completed structure.

4.2.1.2. **Miscellaneous Weld Qualification Test**. A qualified welder must pass a jobsite Miscellaneous Weld Qualification Test before welding:

- Make a single-pass fillet weld of 1/4 in. maximum size in the vertical position approximately 2 in. long on 1/2-in. plate in the location shown in Figure 1. Use the same electrode proposed for the work.
- The Engineer will visually inspect the fillet weld for a reasonably uniform appearance and then rupture the weld as shown in Figure 2 with a force or by striking it with a hammer.
- The fractured surface of the weld will be inspected to ensure complete penetration into the root of the joint, complete fusion to the base metal, and no inclusion or porosity larger than 3/32 in. in its greatest dimension.

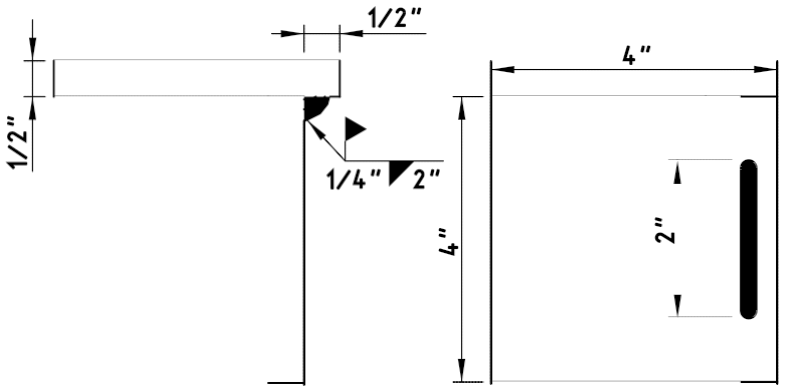


Figure 1
Miscellaneous Qualification—Fillet Weld Break Specimen

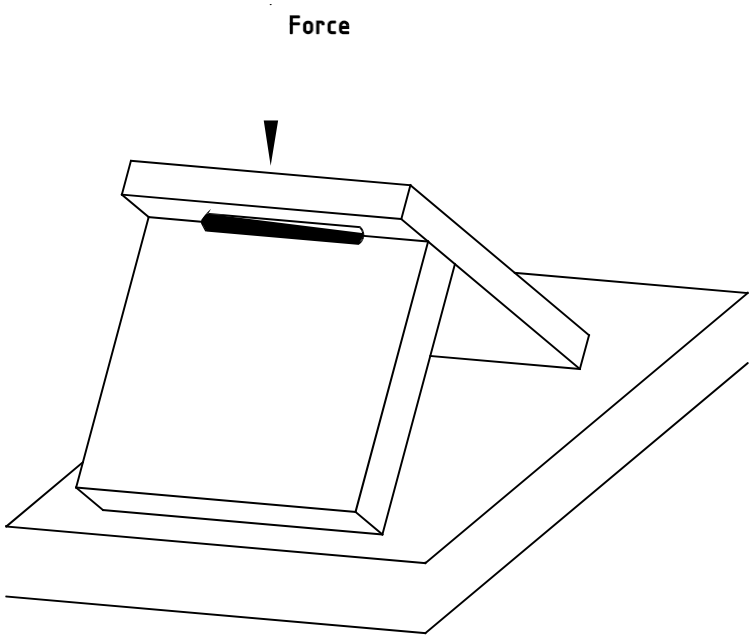


Figure 2
Miscellaneous Qualification—Method of Rupturing Specimen

A welder who fails the Miscellaneous Weld Qualification Test may take a retest under the following conditions:

- The retest occurs immediately and consists of 2 test welds as described above with both test specimens meeting all of the requirements.
- The retest occurs after 30 days if the welder provides evidence of further training or practice. In this case the test consists of a single test weld.

Qualification by the Miscellaneous Weld Qualification Test is effective immediately upon satisfactory completion of the test and remains in effect for the duration of a project.

4.2.2. Certified Steel Structures Welder. Before making non-miscellaneous welds on structural steel, a welder must pass the AASHTO/AWS D1.5 qualification test for groove welds for plates of unlimited thickness in the vertical (3G) and overhead (4G) positions with the following additional requirements:

- Use metal for test plates that meets Item 442, "Metal for Structures," with a minimum yield point of 36 ksi. The minimum width of test plate must be sufficient to accommodate the radiograph inspection of 5-1/4 continuous inches of the weld, not counting the ends of the weld.
- Use approved electrodes meeting the required class in accordance with Table 1 and, in the case of FCAW, in accordance with the approved WPS.
- Have a radiographic inspection performed on the weld on each test plate. Any porosity or fusion-type discontinuity with greatest dimension larger than 1/16 in. found in the weld will result in failure of the test. Discontinuities with greatest dimension less than 1/16 in. are acceptable provided the sum of their greatest dimensions does not exceed 3/8 in. in any inch of weld.
- Have 2 side-bend specimens prepared, tested, and inspected for each test plate.

The test must be administered by an approved laboratory and welding observed by laboratory personnel. Submit 2 copies of the certification issued by the laboratory, all accompanying test papers, and the radiographic films to the Bridge Division for review. The Bridge Division issues Department certification papers if the laboratory's certification is approved. A welder must also demonstrate to the Engineer a thorough knowledge of the required welding procedures together with the ability and desire to follow them and make welds of sound quality and good appearance. The certification issued by an approved laboratory is accepted for 1 mo. from the time of certification, during which time the welder may work on Department projects if the work is satisfactory. Certification papers issued by the Department remain in effect as long as the welder performs acceptable work as determined by the Bridge Division. The certification may be cancelled at any time if the welder's work is not acceptable.

For SMAW, a welder certified using EXX18 electrodes is qualified to weld with all approved SMAW electrodes up to E90XX to join metals with a maximum specified yield strength of 65 ksi.

4.3. Welding Steel Structures.

4.3.1. Electrode Condition.

4.3.1.1. SMAW. For electrodes with low-hydrogen coverings in conformance with AWS A5.1, dry to the manufacturer's written drying instructions or dry for at least 2 hours between 450°F and 500°F. For electrodes with low-hydrogen coverings conforming to AWS A5.5, dry for at least 1 hour between 700°F and 800°F or as specified by the electrode manufacturer. If using electrodes from a newly opened undamaged hermetically sealed container, drying is not required. Store electrodes in ovens held at a temperature of at least 250°F immediately after drying or removal from hermetically sealed container. Elapsed time permitted between removal of an electrode from the storage oven or hermetically sealed container and use of the electrode is given in Table 2. If the electrodes have the moisture resistance designator "R" and are being used on steel with minimum specified yield strength of 50 ksi or less, exposure time may be increased up to 9 hr.

Table 2
SMAW Electrode Exposure Limits

| Electrode Type | Exposure Time (hr.) |
|---|---|
| E70 | 4 |
| E80 | 2 |
| E90 | 1 |

Leave electrodes in the holding oven for at least 4 hr. at 250°F before reusing if they are placed back in it before the times given in Table 2 have lapsed. The Engineer may reduce times allowed for use without re-drying in humid atmospheres. Do not redry electrodes more than once. Do not use electrodes with flux that has been wet, cracked, or otherwise damaged.

4.3.1.2. FCAW. Protect or store welding wire coils removed from the original package to keep their characteristics or welding properties intact. Do not use coils or portions of coils that are rusty.

4.3.1.3. Special Applications. Dry electrodes for fracture-critical applications or when welding steel not shown in Table 1 in accordance with the manufacturer's specifications and AASHTO/AWS D1.5.

4.3.2. Environmental Conditions. Do not weld when the air temperature is lower than 20°F; when surfaces are wet or exposed to rain, snow, or wind; or when operators are exposed to inclement conditions. Provide wind breaks to protect welding operations from winds greater than 5 mph.

4.3.3. Assembly and Fitup. Verify that ends of members to be welded are prepared in accordance with the welded joint detail specified. See Figures 3, 4, and 5 for proper end preparation and weld details of girder splices.

Bring the parts to be joined by fillet welds into as close contact as possible, not separated more than 3/16 in. Increase the leg of the fillet weld by the amount of the separation if the separation is 1/16 in. or more. Keep the separation between faying surfaces of lap joints and of butt joints landing on backing strips to no more than1/16 in.

Make suitable allowance for shrinkage, and never restrain the joint on both sides in any welding process.

Use the following fitup procedure for groove welds for butt joints:

- Align splices of beams and girders joined by groove welds with the center of gravity of both cross-sections coinciding or each flange vertically offset equally. Fit beams and girders with offset webs with the webs aligned and the flanges offset laterally. Make the joint with a smooth transition between offset surfaces and with a slope of no more than1:4 when flanges are offset or abutting parts differ in thickness or width by more than 1/8 in.
- Space members to provide a 3/16-in. root opening at the nearest point. At other points of the joint when the spacing provides up to a 7/16-in. opening, correction may be made by buildup up to 1/8 in. on each bevel nose. Rebevel openings exceeding 7/16 in. and move the parts to be joined closer together to bring the joint within the maximum buildup limits. Allow buildups to cool to the maximum preheat and interpass temperatures before welding the joint.
- Bring all members into correct alignment and hold them in position by acceptable clamps while welding.

Complete all butt splices before welding diaphragms or sway bracing in a particular section of a unit. Diaphragms and sway bracing may be welded in a unit behind the splice welding to provide stability except where such welding interferes with butt splice adjustments, such as at a drop-in segment of a continuous unit. Complete all splices before welding beams or girders to shoes.

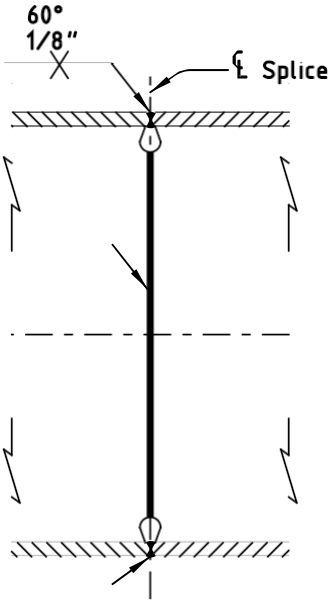


Figure 3
Girder Splice Details

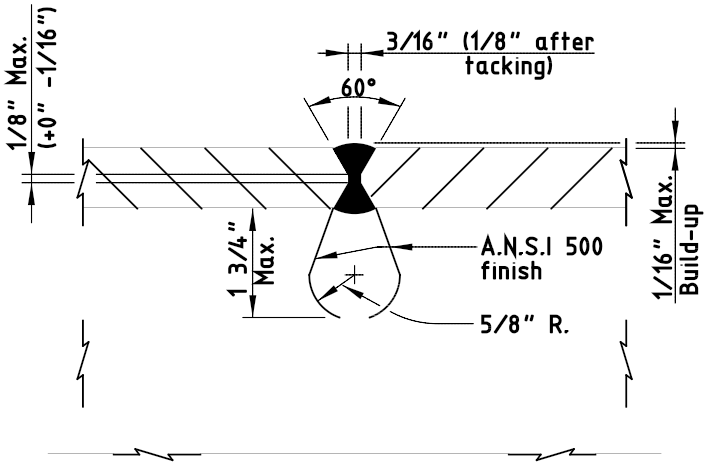


Figure 4
Girder Splice Details (Flange)

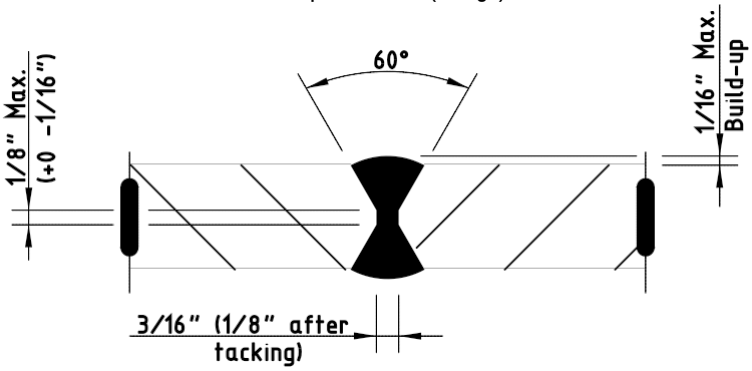


Figure 5
Girder Splice Details (Web)

4.3.4. Preheat. Preheat ahead of welding both groove and fillet welds (including tack welding) to the temperatures shown in Table 3. Keep preheat and interpass temperatures high enough to prevent cracks. The preheat

temperatures shown in Table 3 are minimums, and higher preheats may be necessary in highly restrained welds. Preheat the base metal when it is below the required temperature so that parts being welded are not cooler than the specified temperature within 3 in. of the point of welding.

Measure preheat temperature on the side opposite to which the heat is applied at points approximately 3 in. away from the joint.

Completely weld a joint before allowing it to cool below the specified temperature. Always deposit enough weld to prevent cracking before allowing a joint to cool. Do not allow preheat and interpass temperatures to exceed 400°F for thickness up to 1-1/2 in. and 450°F for greater thicknesses.

Table 3
Minimum Preheat and Interpass Temperature for Welding with Low-Hydrogen Electrodes

| Thickest Part at Point of Welding | Temperature |
|---|---|
| Up to 3/4 in., inclusive | 50°F |
| More than 3/4 in. up to 1-1/2 in., inclusive | 70°F |
| More than 1-1/2 in. up to 2-1/2 in., inclusive | 150°F |
| More than 2-1/2 in. | 225°F |

Preheat the material in accordance with Table 4 when E7010 or E8010 electrodes are used for tacking or temporary root pass.

Table 4
Minimum Preheat Temperature for Welding with E7010 or E8010 Electrodes

| Thickest Part at Point of Welding | Temperature |
|---|---|
| 1/2 in. and less | 150°F |
| 9/16 in. through 3/4 in. | 200°F |
| 13/16 in. through 1-1/2 in. | 300°F |
| More than 1-1/2 in. | 400°F |

Use preheat and interpass temperatures for the thicker plate thickness when joining steels of different thickness.

Preheat base metal to at least 70°F when the base metal temperature is below 32°F. and maintain this minimum temperature during welding. Preheat base metal to 200°F before starting to weld if it is moist.

Preheat fracture-critical applications in accordance with AASHTO/AWS D1.5.

4.3.5. Welding Practice. Use an approved procedure to control shrinkage and distortion. Weld FCAW in accordance with an approved WPS. Weld as required by the Contract or erection drawings. Do not change the location or size of welds without approval. Do not make temporary welds for transportation, erection, or other purposes on main members except as shown on the plans or approved. Use a crayon, paint, or other approved method to mark each groove weld to identify the welder who performed the work.

Use the stringer-bead technique where possible for groove welds. Progress upward in vertical welding passes using a back-step sequence keeping the end of the low-hydrogen electrode contained within the molten metal and shield of flux unless the electrode manufacturer's specifications indicate otherwise.

Begin and terminate groove welds at the ends of a joint on extension bars. Make edge preparation and thickness of extension bars the same as that of the member being welded but extending at least 2 in. beyond the joint. Remove extension bars with a cutting torch or arc-air gouging, and grind the flange edges smooth after the weld is completed and cooled. Clean any defects exposed by the grinding, fill them with weld metal, and regrind them to a uniform finish. Grind so that grind marks are parallel to the flange, and avoid excess grinding of the parent metal. Clean and fuse tack welds thoroughly with the final weld. Remove defective, cracked, or broken tack welds.

Gouge, chip, or otherwise remove the root of the initial weld to sound metal for all groove welds, except those produced with the aid of backing or those on steel piling or armor joints, before welding is started on the second side. Clean the back side thoroughly before placing the backup pass. Fuse the weld metal

thoroughly with the backing, and use backing that is continuous for the full length of the weld. Make a continuous length of backing by welding shorter sections together only under the following conditions:

- All splices in the backing are complete joint penetration (CJP) groove welds made with the same controls as similar CJP groove welds in the structure.
- The welds are radiographed and examined as described in Section 448.4.3.7., "Radiographic Inspection" to ensure weld soundness.
- All welding and testing of the backing is complete before the backing is used to make the structural weld.

4.3.5.1. High-Cellulose Electrodes for Root Passes. E7010 and E8010 electrodes may be used when welding the root passes of beam and girder splices if the work is preheated in accordance with Table 4. Remove the E7010 or E8010 electrode pass completely by arc-air gouging, and replace it using a low-hydrogen electrode after the root passes are backed up.

4.3.5.2. Welding Sequence. Make beam and girder splices using the sequences shown in Figure 6. (Some members will require fewer or more passes than Figure 6 shows.) Alternate welds from flat to overhead to prevent heat buildup along bevel edge. Arrange the passes between the top and bottom flange to maintain balance and symmetry.

Place passes 1, 2, and 3 in the top flange, followed by passes 4, 5, and 6 in the bottom flange (see Figure 6) for rolled I-beams and built-up girders. Gouge out and replace passes 1 and 4, which always are placed in the overhead position. Next, place passes 7, 8, and 9 in the top flange, followed by passes 10, 11, and 12 in the bottom flange. Continue with placing passes 13–17 in the top flange, followed by passes 18–22 in the bottom flange. Continue to alternate welding between top and bottom flange with a maximum of 5 passes per flange until the flange splices are complete. Tack weld web after aligning girder webs with short tacks as required to obtain proper alignment. Place pass 23 and pass 24 on the web. Gouge out and replace pass 23. Finish web splice with pass 25.

Remove all slag for each layer, bead, and the crater area, and clean the weld and adjacent base metal before welding over previously deposited metal. Avoid arc strikes, and if they occur, grind resulting cracks and blemishes out to a smooth contour, checking them visually to ensure soundness.

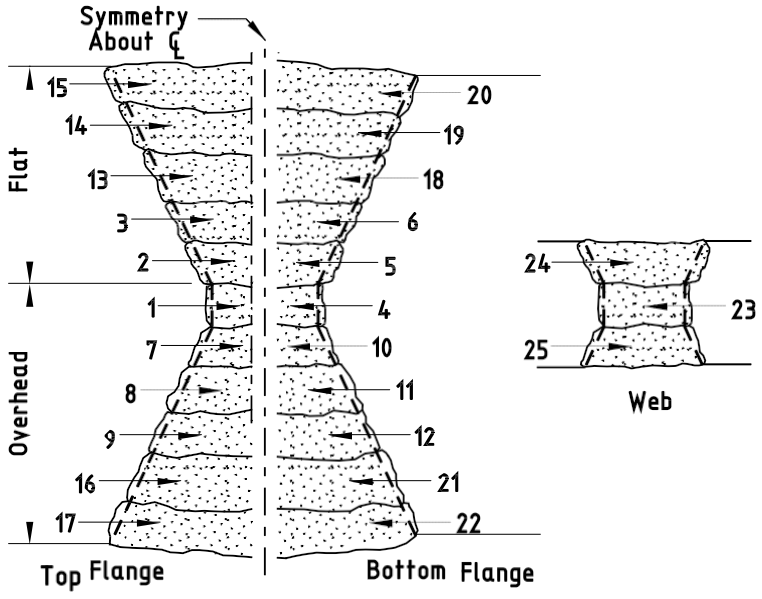


Figure 6
Welding Sequence for Splices for Material up to 50,000-psi Yield Strength.

Deviation from the above sequence of weld passes requires approval. Obtain approval from the Bridge Division for welding procedures and sequences for special connections.

4.3.5.3. Electrode Size and Weld Layer Thickness.

4.3.5.3.1. SMAW.

4.3.5.3.1.1. Electrode Size. Use electrodes with the following maximum size:

- 1/4 in. for all welds made in the flat position except root passes,
- 1/4 in. for horizontal fillet welds,
- 1/4 in. for root passes of fillet welds made in the flat position and of groove welds made in the flat position with backing and with a root opening of 1/4 in. or more,
- 5/32 in. for welds made with low-hydrogen electrodes in the vertical and overhead positions, and
- 3/16 in. for all other welds.

4.3.5.3.1.2. Weld Size and Layer Thickness. Make the root pass large enough to prevent cracking. Make layers subsequent to the root pass in fillet welds and all layers in groove welds of the following maximum thickness:

- 1/4 in. for root passes of groove welds;
- 1/8 in. for subsequent layers of welds made in the flat position; and
- 3/16 in. for subsequent layers of welds made in the vertical, overhead, and horizontal positions.

Make fillet welds passes using no larger than:

- 3/8 in. in the flat position,
- 5/16 in. in the horizontal or overhead positions, and
- 1/2 in. in the vertical position.

4.3.5.3.2. FCAW.

4.3.5.3.2.1. Electrode Size. Use electrodes with the following maximum size:

- 5/32 in. for the flat and horizontal positions,
- 3/32 in. for the vertical position, and
- 5/64 in. for the overhead position.

4.3.5.3.2.2. Weld Size and Layer Thickness. Make weld layers, except root and surface layers, no thicker than 1/4 in. Use a multiple-pass split-layer technique when the root opening of a groove weld is 1/2 in. or wider. Use the split-layer technique to make all multiple-pass welds when the width of the layer exceeds 5/8 in.

Ensure each pass has complete fusion with adjacent base metal and weld metal and that there is no overlap, excessive porosity, or undercutting.

Do not use FCAW with external gas shielding in a draft or wind. Furnish an approved shelter of material and shape to reduce wind velocity near the welding to a maximum of 5 mph.

Make fillet weld passes using no larger than:

- 1/2 in. in the flat position,
- 3/8 in. in the horizontal or overhead positions, and
- 5/16 in. in the vertical position.

4.3.6. Weld Quality. Provide welds that are sound throughout with no cracks in the weld metal or weld pass. Completely fuse the weld metal and the base metal and each subsequent pass. Keep welds free from overlap, and keep the base metal free from undercut more than 1/100 in. deep when the direction of undercut is transverse to the primary stress in the part that is undercut. Fill all craters to the full cross-section of the welds.

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4.3.7. Radiographic Inspection. Conduct radiographic testing (RT) as required in the field at the expense of the Contractor by an agency or individual registered and licensed to perform industrial radiography. Follow all applicable rules and regulations for radiographic operations. Testing includes furnishing all materials, equipment, tools, labor, and incidentals necessary to perform the required testing. The Department may require further tests in accordance with Article 5.10., "Inspection," and may perform additional testing, including other methods of inspection.

Perform RT in accordance with AASHTO/AWS D1.5. The Engineer will examine and interpret the resulting radiographs in accordance with AASHTO/AWS D1.5. All radiographs become the property of the Department and remain with the Engineer.

Radiographically inspect the full flange width of all flange splices and the top and bottom 1/6 of the web at each splice for field-welds of splices in beams or girders. Radiographically retest repaired welds. Make necessary repairs before any further work is done. Additional RT required because of unacceptable welding or poor radiograph quality is at the Contractor's expense. RT of particular welds required by the plans is in addition to the RT required by this Item.

Meet the requirements specified in Section 441.3.2.5.1., "Radiographic Testing" for radiograph film quality.

4.3.8. Corrections. When welding is unsatisfactory or indicates inferior workmanship, the Engineer will require corrective measures and approve the subsequent corrections.

Use oxygen gouging or arc-air gouging when required to remove part of the weld or base metal. Back-gouge splices in beams and girders or cut out defective welds using arc-air gouging by a welder qualified to make beam and girder splices.

Slope the sides of the area to be welded enough to permit depositing new metal were corrections require depositing additional weld metal.

Use a smaller electrode than that used for the original weld where corrections require depositing additional weld metal. Clean surfaces thoroughly before re-welding.

Remove cracked welds completely and repair. Remove the weld metal for the length of the crack if crack length is less than half the length of the weld plus 2 in. beyond each end of the crack, and repair.

Restore the original conditions where work performed after making a deficient weld has made the weld inaccessible or has caused new conditions making the correction of the deficiency dangerous or ineffectual by removing welds, members, or both before making the necessary corrections; otherwise, compensate for the deficiency by performing additional work according to a revised and approved design.

Cut apart and re-weld improperly fitted or misaligned parts.

Straighten members distorted by the heat of welding using mechanical means or the carefully supervised application of a limited amount of localized heat. Do not let heated areas exceed 1,200°F as measured by temperature-indicating crayons or other approved methods for steel up to 65,000-psi yield strength. Do not let heated areas exceed 1,100°F for higher-strength steels. Keep parts to be heat-straightened substantially free of stress from external forces except when mechanical means are used with the application of heat. Before straightening, submit a straightening procedure to the Engineer for approval.

Correct defective or unsound welds either by removing and replacing the entire weld or as follows:

4.3.8.1. Excessive Convexity. Reduce to size by grinding off the excess weld metal, leaving a smooth profile.

4.3.8.2. Shrinkage Cracks, Cracks in Base Metal, Craters, and Excessive Porosity. Remove defective portions of base and weld metal down to sound metal, and replace with additional sound weld metal.

4.3.8.3. Undercut, Undersize, and Excessive Concavity. Clean and deposit additional weld metal.

4.3.8.4. Overlap and Incomplete Fusion. Remove and replace the defective portion of weld.

4.3.8.5. Slag Inclusions. Remove the parts of the weld containing slag, and replace them with sound weld metal.

4.3.8.6. Removal of Base Metal during Welding. Clean and form full size by depositing additional weld metal using stringer beads.

4.4. Shear Stud Welding. Weld shear studs to steel surfaces and perform preproduction and production tests as required in AASHTO/AWS D1.5.

4.5. Welding Reinforcing Steel. Splice reinforcing steel by welding only at locations shown on the plans.

4.5.1. Base Metal. Provide weldable reinforcing steel in conformance with Item 440, "Reinforcement for Concrete."

4.5.2. Preheat and Interpass Temperature. Minimum preheat and interpass temperatures are shown in Table 5. Preheat reinforcing steel when it is below the listed temperature for the size and carbon equivalency range of the bar being welded so that the cross-section of the bar is above the minimum temperature for at least 6 in. on each side of the joint. Allow bars to cool naturally to ambient temperature after welding is complete. Do not accelerate cooling.

Table 5
Minimum Preheat and Interpass Temperature for Reinforcing Steel

| Carbon Equivalent Range (%) | Size of Reinforcing Bar (no.) | Temperature (°F) |
|---|---|---|
| Up to and including 0.40 | Up to 11 inclusive | None |
| | 14 and 18 | 50 |
| 0.41 through 0.45 inclusive | Up to 11 inclusive | None |
| | 14 and 18 | 100 |
| 0.46 through 0.55 inclusive | Up to 6 inclusive | None |
| | 7 to 11 inclusive | 50 |
| | 14 and 18 | 200 |
| Unknown | Up to 18 inclusive | 500 |

Base the preheat and interpass temperatures for widening projects on the existing reinforcing steel and the requirements of Table 5.

4.5.3. Joint Types. Use butt splices for all No. 7 and larger bars. Use lap splices for No. 6 and smaller bars.

Make groove welds in lap splices at least 4 in. long, and weld them on each side of the lap joint as shown in Figure 7. For No. 5 and smaller bars, weld from one side of the lap when it is impractical to weld from both sides of the joint if approved by the Engineer, but in this case make the weld at least 6 in. long.

Make all butt splices in the flat position. Make all welds for butt splices, except horizontal welds on vertical bars, as shown in Figures 8 and 9. The back-up strip is required when access to the splice is from the top only. When bars can be rotated or access to the splice is available from 2 sides, the double bevel splice may be used, and this type weld requires gouging out the root pass similar to a flange splice on structural steel. The root pass may be made using E7010 or E8010 electrodes for all double beveled splices. Preheat the steel to 400°F, if using E7010 or E8010 electrodes, and then completely remove the root pass before welding the opposite side. Make horizontal splices on vertical bars as shown in Figure 10. Provide alignment strips as shown in Figures 9 and 10 to hold bars during welding operation. Trim alignment strips after welding is complete.

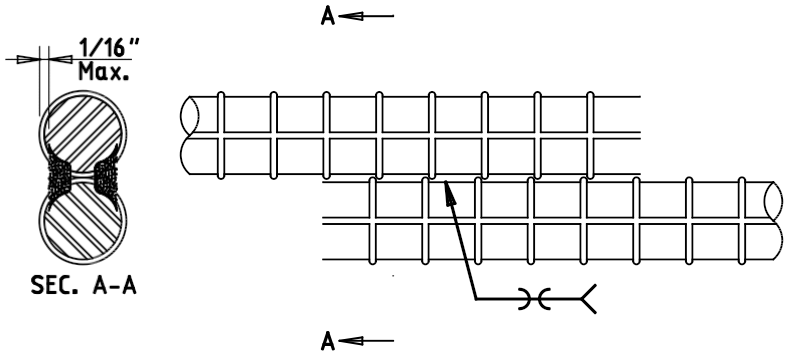


Figure 7
Direct Lap Joint with Bars in Contact

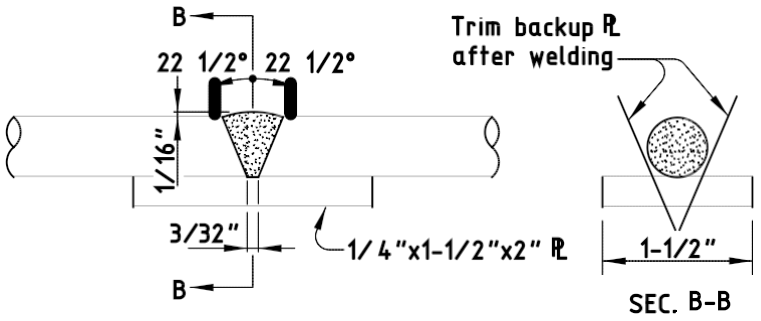


Figure 8
Single Bevel V-Groove Weld in Horizontal Position

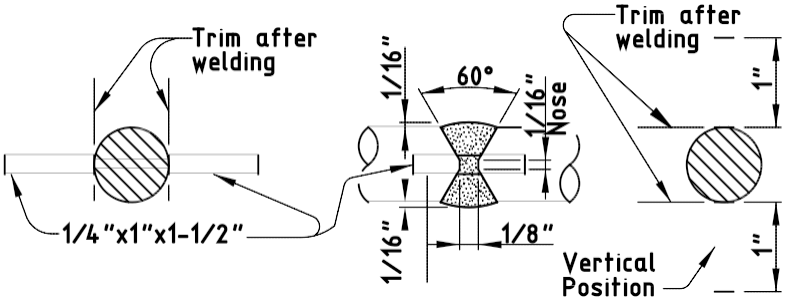


Figure 9
Double Bevel V-Groove Weld in Horizontal Position

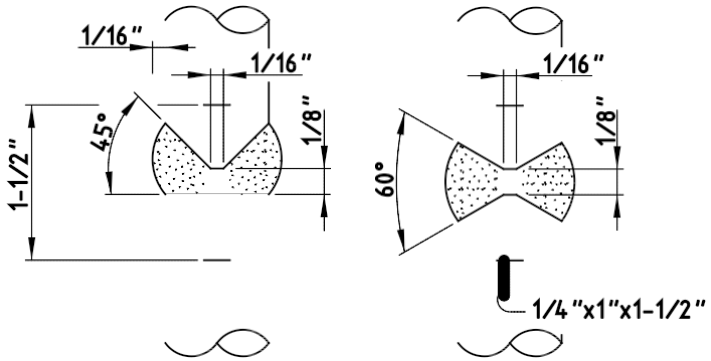


Figure
10
Double Bevel V-Groove Weld in Vertical
Position

4.5.4. Radiographic Inspection. Radiograph welded butt splices at the expense of the Contractor when designated on the plans. Follow all applicable rules and regulations for radiographic operations. Ensure welds have no cracks and that the sum of the greatest dimensions of porosity and fusion-type defects do not exceed 1/10 of the nominal bar diameter.

The Engineer will examine and interpret the resulting radiographs, which become the property of the Department and remain with the Engineer.

## 5. 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 465
# Junction Boxes, Manholes, and Inlets

## 1. DESCRIPTION

Construct junction boxes, manholes, and inlets, complete in place or to the stage detailed, including furnishing and installing frames, grates, rings, and covers.

## 2. MATERIALS

Furnish materials in accordance with the following:

- Item 421, "Hydraulic Cement Concrete"
- Item 440, "Reinforcement for Concrete"
- Item 471, "Frames, Grates, Rings, and Covers"

Cast-in-place junction boxes, manholes, inlets, risers, and appurtenances are acceptable unless otherwise shown. Alternate designs for cast-in-place items must be acceptable to the Engineer and must conform to functional dimensions and design loading. Alternate designs must be designed and sealed by a licensed professional engineer.

2.1. Concrete. Furnish Class H concrete as referenced in Item 421 "Hydraulic Cement Concrete," except that Mix Design Options 1–8 will be allowed for formed precast junction boxes, manholes, and inlets. Furnish concrete per DMS-7310, "Reinforced Concrete Pipe and Machine-Made Precast Concrete Box Culvert Fabrication and Plant Qualification," for machine-made precast junctions boxes, manholes, and inlets. Furnish Class C concrete for cast-in-place manholes and inlets unless otherwise shown on the plans.

2.2. Mortar. Furnish mortar conforming to DMS-4675, "Cementitious Grouts and Mortars for Miscellaneous Applications."

2.3. Timber. Provide sound timber that is a minimum of 3 in. nominal thickness and reasonably free of knots and warps for temporary covers when used with Stage I construction (see Article 465.3., "Construction").

2.4. Other Materials. Use commercial-type hardware as approved.

## 3. CONSTRUCTION

Construct all types of junction boxes, manholes, and inlets either complete or in 2 stages, described as Stage I and Stage II.

Construct the Stage I portion of junction boxes, manholes, and inlets as shown on the plans or as specified in this Item. Furnish and install a temporary cover as approved.

Furnish and install the storm drain pipe and a temporary plug for the exposed end of the storm drain pipe from the storm drain to a point below the top of curb indicated on the plans for Stage I construction of cast iron or steel inlet units.

Construct Stage II after the pavement structure is substantially complete unless otherwise approved.

Construct the remaining wall height and top of junction box, manhole, or inlet for Stage II, and furnish and install any frames, grates, rings and covers, curb beams, or collecting basins required.

Forms will be required for all concrete walls. Outside wall forms for cast-in-place concrete may be omitted with approval if the surrounding material can be trimmed to a smooth vertical face.

3.1. **Precast Junction Boxes, Manholes, and Inlets**. Construct machine-made precast junction boxes, manholes, and inlets in accordance with ASTM C478 except as otherwise noted in this Item. Mix and place concrete for machine-made junction boxes, manholes, and inlets per the requirements of DMS-7310, "Reinforced Concrete Pipe and Machine-Made Precast Concrete Box Culvert Fabrication and Plant Qualification." Conform to the product permissible variations and rejection criteria stated in ASTM C478 for machine-made precast junction boxes, manholes, and inlets.

Multi-project fabrication plants (as defined in Item 424 "Precast Concrete Structural Members (Fabrication)," that produce manholes and inlets will be approved by the Construction Division in accordance with DMS-7340, "Qualification Procedure for Multi-Project Fabrication Plants of Precast Concrete Manholes and Inlets." The Department's MPL has a list of approved multi-project plants.

3.1.1. **Lifting Holes**. Provide no more than 4 lifting holes in each section for precast units. Lifting holes may be cast, cut into fresh concrete after form removal, or drilled. Provide lifting holes large enough for adequate lifting devices based on the size and weight of the section. The maximum hole diameter is 3 in. at the inside surface of the wall and 4 in. at the outside surface. Cut no more than 5 in. in any direction of reinforcement per layer for lifting holes. Repair spalled areas around lifting holes.

3.1.2. **Marking**. Clearly mark each precast junction box, manhole, and inlet unit with the following information:

- name or trademark of fabricator and plant location;
- product designation;
- ASTM designation (if applicable);
- date of manufacture;
- designated fabricator's approval stamp; and
- designation "SR" for product meeting sulfate-resistant concrete plan requirements (when applicable).

3.1.3. **Storage and Shipment**. Store precast units on a level surface. Do not ship units until design strength requirements have been met.

3.2. **Excavation, Shaping, Bedding, and Backfill**. Immediate backfilling is permitted for all junction box, manhole, and inlet structures where joints consist of rubber boots, rubber gaskets, or bulk or preformed joint sealant. Take precautions in placing and compacting the backfill to avoid any movement of junction boxes, manholes, and inlets. Remove and replace junction boxes, manholes, and inlets damaged by the Contractor at no expense to the Department.

3.3. **Junction Boxes, Manholes, and Inlets for Precast Concrete Pipe Storm Drains**. Construct junction boxes, manholes, and inlets for precast concrete pipe storm drains before completion of storm drain lines into or through the junction box, manhole, or inlet. Neatly cut all storm drains at the inside face of the walls of the junction box, manhole, or inlet.

3.4. **Junction Boxes, Manholes, and Inlets for Box Storm Drains**. Place bases or risers of junction boxes, manholes, and inlets for box storm drains before or in conjunction with placement of the storm drain. Backfill the junction box, manhole, or inlet and storm drain as a whole.

3.5. **Inverts**. Shape and route floor inverts passing out or through the junction box, manhole, or inlet as shown on the plans. Shape by adding and shaping mortar or concrete after the base is placed or by placing the required additional material with the base.

3.6. **Finishing Complete Junction Boxes, Manholes, and Inlets**. Complete junction boxes, manholes, and inlets in accordance with the plans.

3.7. **Finishing Stage I Construction**. Complete Stage I construction by constructing the walls to the elevations shown on the plans and backfilling to required elevations.

3.8. **Stage II Construction**. Construct subgrade and base course or concrete pavement construction over Stage I junction box, manhole, or inlet construction unless otherwise approved. Excavate to expose the top of Stage I construction and complete the junction box, manhole or inlet in accordance with the plans and these Specifications, including backfill and cleaning of all debris from the bottom of the junction box, manhole, or inlet.

3.9. **Inlet Units**. Install cast iron or steel inlet units in conjunction with the construction of concrete curb and gutter. Set the inlet units securely in position before placing concrete for curb and gutter. Form openings for the inlets and recesses in curb and gutter as shown on the plans. Place and thoroughly consolidate concrete for curb and gutter adjacent to inlets and around the inlet castings and formed openings and recesses without displacing the inlet units.

## 4. MEASUREMENT

All junction boxes, manholes, and inlets satisfactorily completed in accordance with the plans and specifications will be measured by each junction box, manhole, or inlet, complete, or by each junction box, manhole, or inlet completed to the stage of construction required by 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 as follows:

5.1. **Complete Manholes**. Payment for complete manholes will be made at the unit price bid for "Manhole (Complete)" of the type specified.

5.2. **Complete Inlets**. Payment for inlets will be made at the unit price bid for "Inlet (Complete)," of the type specified.

5.3. **Complete Junction Boxes**. Payment for junction boxes will be made at the unit price bid for "Junction Box (Complete)" of the type specified.

5.4. **Manholes Stage I**. Payment for Manholes, Stage I, will be made at the unit price bid for each "Manhole (Stage I)" of the type specified.

5.5. **Manholes Stage II**. Payment for Manholes, Stage II, will be made at the unit price bid for each "Manhole (Stage II)" of the type specified.

5.6. **Inlets Stage I**. Payment for Inlets, Stage I, will be made at the unit price bid for each "Inlet (Stage I)" of the type specified.

5.7. **Inlets Stage II**. Payment for Inlets, Stage II, will be made at the unit price bid for each "Inlet (Stage II)" of the type specified.

5.8. **Junction Boxes Stage I**. Payment for Junction Boxes, Stage I, will be made at the unit price bid for each "Junction Box (Stage I)" of the type specified.

5.9. **Junction Boxes Stage II.** Payment for Junction Boxes, Stage II, will be made at the unit price bid for each "Junction Box (Stage II)" of the type specified.

This price is full compensation for concrete, reinforcing steel, mortar, frames, grates, rings and covers, excavation, and backfill and for all other materials, tools, equipment, labor, and incidentals.

# Item 471
# Frames, Grates, Rings, and Covers

## 1. DESCRIPTION

Furnish and install frames, grates, rings, and covers for inlets, manholes, and other structures.

## 2. MATERIALS

2.1. **Frame, Grate, Ring, and Cover Castings**. Provide clean castings conforming to the shape and dimensions shown on the plans. Ensure all gray and ductile iron castings conform to the AASHTO Designation M 306. Cast or machine the bearing surfaces for traffic service castings between manhole rings and covers and between grates and frames with such precision as to prevent rocking.

Provide gray iron castings in accordance with ASTM A48 Class 35B and AASHTO M 306 for traffic service applications unless otherwise specified. Provide gray iron castings in accordance with ASTM A48 Class 35B for sidewalk or pedestrian applications unless otherwise specified. Provide ductile iron castings in accordance with ASTM A536, Grade 70-50-05, unless otherwise specified. Provide steel castings in accordance with ASTM A27, Grade 70-36, unless otherwise specified. Ensure all traffic service castings and gratings meet or exceed the H20 proof-load requirements of AASHTO M 306. Load test results and material certifications must be made available upon request.

Ensure all traffic service (heavy duty) rated castings and grating meet the proof-load testing requirements of AASHTO M 306. Ensure all load tests are conducted with a calibrated NIST certified load cell. Ensure materials are loaded with a 9 × 9-in. load block to an applied load of 40,000 lb. for one minute without deformation or failure. Load test results and material certifications must be made available upon request.

Provide castings within ±1/16 in. per foot of plan dimensions, and within ±5% of plan weight.

2.2. **Welded Steel Grates and Frames**. Provide welded steel grates and frames as an assembly in accordance with the member size, dimensions, and details shown on the plans. Use steel that meets ASTM A36 or equivalent.

2.3. **Documentation**. Furnish a manufacturer's certification stating the casting meets the proof-load testing requirements of AASHTO M 306 for traffic service castings.

## 3. CONSTRUCTION

Construct and install frames, grates, rings, and covers in accordance with the details shown on the plans. Tack weld grates and covers to the frame or ring when directed.

Galvanizing is not required for iron castings unless used in conjunction with structural steel shapes or shown on the plans.

## 4. MEASUREMENT

Frames, grates, rings, and covers, when a part of the complete manhole or inlet, will not be measured for payment but will be considered subsidiary to Item 465, “Junction Boxes, Manholes, and Inlets.” Frames, grates, rings, and covers, when not a part of a Manhole (complete) or Inlet (complete), will be measured by the each.

## 5. PAYMENT

When payment is required in accordance with “Measurement,” payment for frames, grates, rings, and covers will be made at the unit price bid for “Grate,” “Frame,” “Grate and Frame,” “Frame and Cover,” or “Ring and Cover” with the type and number of grates specified, if necessary. This price is full compensation for equipment, materials, labor, tools, and incidentals.

# Item 476
# Jacking, Boring, or Tunneling Pipe or Box

## 1. DESCRIPTION

Furnish and install pipe or box by jacking, boring, or tunneling.

## 2. MATERIALS

Use the following types of pipe or box specified on the plans.

## 3. CONSTRUCTION

Excavate suitable shafts or trenches for conducting the jacking, boring, or tunneling operations and for placing end joints of the pipe or box if the grade at the jacking, boring, or tunneling end is below the ground surface. Maintain a 3:1 slope from edge of pavement on the shaft side of the road unless otherwise shown or directed. Provide a positive barrier when the shaft location is within the clear zone of the roadway. Protect excavations deeper than 5 ft. as specified in Item 402, “Trench Excavation Protection”.

Install pipe or box so there is no interference with the operation of street, highway, railroad, or other facility and no embankment or structure is weakened or damaged.

Repair any pipe or box damaged in jacking, boring, or tunneling. Remove and replace any pipe or box damaged beyond repair at the Contractor’s expense.

Backfill shafts or trenches excavated to facilitate jacking, boring, or tunneling immediately after installation of pipe or box.

3.1. Jacking. Provide jacks suitable for forcing the pipe or box through the embankment. Use even pressure to all jacks during operation. Provide a suitable jacking head and suitable bracing between the jacks and the jacking head to apply uniform pressure around the ring of the pipe or circumference of the box. Use joint cushioning of plywood or other approved material. For plywood cushioning material, use 1/2-in. minimum thickness for pipe diameter 30 in. or less, and use 3/4-in. minimum thickness for pipe diameter greater than 30 in. Use 3/4-in. minimum thickness for all boxes. Use cushioning rings of single or multiple pieces. Provide a suitable jacking frame or backstop. Set the pipe or box to be jacked on guides that support the section of the pipe or box, and direct it on the proper line and grade. Place the entire jacking assembly in line with the direction and grade of the pipe or box. In general, excavate the embankment material just ahead of the pipe or box, remove the material through the pipe or box, and force the pipe or box through the embankment with jacks into the space bored or tunneled.

Furnish a plan showing the proposed method of jacking for approval. Include the design for the jacking head, jacking support or backstop (thrust block), arrangement and position of jacks, and guides in the plan.

Ensure excavation for the underside of the pipe for at least 1/3 of the circumference of the pipe conforms to the contour and grade of the pipe. Ensure the excavation for the bottom slab of the box conforms to the grade of the box. Over-excavate, if desired, to provide no more than 2 in. of clearance for the upper portion and sides of the pipe or box. Taper this clearance to zero at the point where the excavation conforms to the contour of the pipe or box. Carry out jacking without interruption to prevent the pipe from becoming firmly set in the embankment. Monitor volume of soil excavated to avoid any appreciable over excavation. Pressure-grout any over excavation of more than 1 in. Pressure-grout between the carrier pipe and casing when shown on the plans.

The distance the excavation extends beyond the end of the pipe or box must not exceed 2 ft. Decrease this distance as necessary to maintain stability of the material being excavated.

Jack the pipe or box from the low or downstream end. The final position of the pipe or box must not vary from the line and grade shown on the plans by more than 1 in. in 10 ft. Variation must be regular and in one direction, and the final flow line must be in the direction shown on the plans.

Use a shield or cutting edge of steel plate around the head end of the pipe or box extending a short distance beyond the end if desired. The minimum distance for parallel pipe or box jacking or tunneling is 3 ft. or 2 times the diameter of the pipe or width of box, whichever is greater, unless otherwise shown on the plans.

3.2. Boring or Tunneling. Bore from a shaft in an approved location provided for the boring equipment and workmen.

Dispose of excavated material using an approved method. Use water or other appropriate drilling fluids in connection with the boring operation only as necessary to lubricate cuttings and pipe or box; do not use jetting.

Use a gel-forming colloidal drilling fluid consisting of high-grade, carefully processed bentonite to consolidate cuttings of the bit in unconsolidated soil formations. Seal the walls of the bore hole and furnish lubrication for subsequent removal of cuttings and immediate installation of the pipe.

Allowable variations from line and grade are specified in Section 476.3.1., “Jacking.” Pressure-grout any over excavation of more than 1 in.

3.2.1. Larger Diameter Boring Methods. Use the pilot hole or auger method for drainage and large utility borings. Pressure-grout any over excavation of more than 1 in. Pressure-grout between the carrier pipe and casing when shown on the plans.

3.2.1.1. Pilot Hole Method. Bore a 2-in. pilot hole the entire length of the crossing, and check it for line and grade during the boring or tunneling operation on the opposite end of the bore from the work shaft. This pilot hole will serve as centerline for the larger diameter hole to be bored.

3.2.1.2. Auger Method. Use a steel encasement pipe of the appropriate diameter equipped with a cutter head to mechanically perform the excavation. Use augers of large enough diameter to convey the excavated material to the work shaft.

3.2.2. Electrical and Communication Conduit Boring. Limit over excavation to the dimensions shown in Table 1 for electrical and communication conduit borings. Increased boring diameters will be allowed for outer diameters of casing and couplings. Pressure-grouting will not be required for electrical and communication conduit borings.

Table 1
Allowable Bore Diameter for Electrical or Communication Conduit or Casing

| Single Conduit Bores | | Multiple Conduit Bores | |
|---|---|---|---|
| Conduit Size (in.) | Maximum Allowable Bore (in.) | Conduit Size (in.)[1] | Maximum Allowable Bore (in.) |
| 2 | 4 | 4 | 6 |
| 3 | 6 | 5 | 8 |
| 4 | 6 | 6 | 10 |
| 6 | 10 | 7 | 12 |
| | | 8 | 12 |

1. The diameter of multiple conduits is the sum of the outside diameter of the 2 largest conduits for placement of up to 4 conduits in one bore. Submit boring diameters for the Engineer's approval when more than 4 conduits are to be placed in a bore.

3.3. Tunneling. Use an approved tunneling method where the characteristics of the soil, the size of the proposed pipe, or the use of monolithic pipe would make the use of tunneling more satisfactory than jacking or boring, or when shown on the plans.

Ensure the lining of the tunnel is strong enough to support the overburden when tunneling is permitted. Submit the proposed liner method for approval. Approval does not relieve the Contractor of the responsibility for the adequacy of the liner method.

Pressure-grout the space between the liner plate and the limits of excavation.

Pressure-grout between the carrier pipe and liner plate when shown on the plans.

3.4. Joints. Make joints by field bolting or connecting bands, whichever is feasible if corrugated metal pipe is used.

## 4. MEASUREMENT

This Item will be measured by the foot between the ends of the pipe or box along the flow line.

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 "Jacking, Boring, or Tunneling Pipe" of the type, size, and class specified; or "Jacking, Boring, or Tunneling Pipe" of the type, size, and design specified; or "Jacking or Tunneling Box Culvert" of the size specified.

This price is full compensation for excavation, grouting, backfilling, and disposal of surplus material; furnishing pipe, box, and pipe liner materials required for tunnel operations; preparation, hauling, and installing of pipe, box, and pipe liner materials; and materials, tools, equipment, labor, and incidentals.

Protection methods for open excavations deeper than 5 ft. will be measured and paid for as required under Item 402, "Trench Excavation Protection".

# Item 479
# Adjusting Manholes and Inlets

## 1. DESCRIPTION

Adjust or cap existing manholes or inlets. Drainage junction boxes will be classified as manholes.

## 2. MATERIALS

Reuse removed manhole and inlet rings, plates, grates, and covers if they are in good condition as determined by the Engineer. Provide additional materials in accordance with Item 465, "Junction Boxes, Manholes, and Inlets," at no cost to the Department. Use single- or multiple-piece prefabricated metal, polymer, plastic, or rubber extension rings for the adjustment of manholes as approved. Limit the height of flexible extension rings to 3 in.

Ensure frames and grates, or rings and covers, above grade are of single-piece cast iron manufactured in compliance with Item 471, "Frames, Grates, Rings, and Covers." Provide steel riser material compliant with ASTM A36. Provide steel adjustable risers that include a stainless steel adjustable stud with positive lock that adjusts the diameter ±3/8 in. Provide steel risers that include a minimum of 3 allen head set screws that lock the riser to the manhole or catch basin frame. Ensure seating surfaces are flat and true and provide a non-rocking seating surface.

## 3. CONSTRUCTION

Perform all work in accordance with Item 465, "Junction Boxes, Manholes, and Inlets. Carefully remove manhole and inlet rings, covers, plates, and grates to be reused. Clean mortar and grease from the contact areas of all reused items. Dispose of unused removed material as directed. Use construction methods described in
Section 479.3.1., "Lowering the Top of a Manhole or Inlet," and Section 479.3.2., "Raising the Top of a Manhole or Inlet," unless otherwise shown on the plans.

3.1. Lowering the Top of a Manhole or Inlet. Remove a sufficient depth of brick courses or concrete to permit reconstruction on a batter not exceeding 1 in. horizontal to 2 in. vertical. Clean the mortar from the top course of brick where brickwork is present. Rebuild the manhole or inlet to the original top dimensions or to the dimensions shown on the plans. Install the manhole or inlet ring and the cover, plate, or grate to conform to the proposed new surface contour.

3.2. Raising the Top of a Manhole or Inlet. Clean the top surface of brick or concrete. Construct to the proper new elevation using new rubber extension rings, concrete rings, or Class A concrete. Provide rubber manhole and catch basin risers of minimum 80% by weight recycled rubber and minimum 10% by volume recycled RFL coated fiber. Provide rubber manhole and catch basin adjustment risers that are of uniform quality, free from cracks, holes, and any other surface defects. Construction must be suitable for AASHTO H20 live loads. Load certifications for materials will be made available upon request. Install the manhole or inlet ring and the cover, plate, or grate to conform to the proposed new surface contour. Install prefabricated extension rings in accordance with manufacturer's instructions.

3.3. Capping an Inlet or Manhole. Remove the inlet or manhole to a minimum of 1 ft. below subgrade elevation or as indicated on the plans. Cap as shown on the plans.

## 4. MEASUREMENT

Adjusted or capped manholes or inlets will be measured as each manhole or inlet adjusted.

## 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 “Adjusting Manholes,” “Adjusting Inlets,” or “Adjusting Manholes and Inlets.” This price is full compensation for materials, including backfill as required, and for excavation, tools, equipment, labor, 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 personnelwith 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 502.4.5., "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 502.4.2., "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 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 421, "Hydraulic Cement Concrete"
- Item 440, "Reinforcement for Concrete"

2.1.2. **Steel.** Barrier sections will be furnished by the Department or Contractor 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 non-approved 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 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.

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 concrete traffic barrier or connecting hardware damaged by the Contractor's operations at the Contractor's expense.

Repair or replace any pavement damaged in the process of installing, moving, or removing barrier 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 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.

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 520
# Weighing and Measuring Equipment

## 1. DESCRIPTION

Provide weighing and measuring equipment for materials measured or proportioned by weight or volume.

## 2. EQUIPMENT

Provide certified scales, scale installations, and measuring equipment meeting the requirements of *NIST Handbook 44*, except that the required accuracy must be 0.4% of the material being weighed or measured.

Provide personnel, facilities, and equipment for checking the scales as approved. Check all weighing and measuring equipment after each move and at least once each 6 mo. or when requested.

Calibrate all scales using weights certified by the Texas Department of Agriculture (TDA) or an equivalent agency as approved. Provide a written calibration report from a scale mechanic for all calibrations. Cease plant operations during the checking operation. Do not use inaccurate or inadequate scales. Bring performance errors as close to zero as practicable when adjusting equipment.

Furnish enough certified weights to check the accuracy and sensitivity of the scales. Insulate scales against shock, vibrations, or movement of other operating equipment. Provide an automated ticket printout for each truckload of material on a daily basis where payment is determined by weight. Each loading ticket must show the ticket number, truck number, gross weight, tare weight, and net weight.

Provide a summary spreadsheet that lists separately the ticket number, truck number, gross weight, tare weight, net weight, overload weight, and payment weight amounts as shown in Table 1 if required on the plans for materials paid by the ton. Provide this spreadsheet:

- for each lot when materials are paid for in increments of sublots or lots, and
- daily for other materials.

Provide the totals for net weight and overload amounts to be deducted for all summary sheets within 2 days of delivery of materials. Include the overload deduction in the total amount reported for payment. Submissions are subject to verification.

Table 1
Example Spreadsheet

| Ticket No. | Truck No. | Gross Wt. | Tare Wt. | Net Wt. | Overload Wt. | Payment Wt. |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| | | | | Totals | Totals | Totals |

Furnish leak-free weighing containers large enough to hold a complete batch of the material being measured.

2.1. Truck Scales. Furnish platform truck scales capable of weighing the entire truck or truck–trailer combination in a single draft.

2.2. Aggregate Batching Scales. Equip scales used for weighing aggregate with a quick adjustment at zero that provides for any change in tare. Provide a visual means that indicates the required weight for each aggregate.

2.3. Suspended Hopper. Provide a means for the addition or the removal of small amounts of material to adjust the quantity to the exact weight per batch. Ensure the scale equipment is level.

2.4. Belt Scales. Use belt scales for proportioning aggregate that are accurate to within 1.0% based on the average of 3 test runs, where no individual test run exceeds 2.0% when checked in accordance with Tex-920-K.

2.5. Asphalt Material Meter. Provide an asphalt material meter with an automatic digital display of the volume or weight of asphalt material. Verify the accuracy of the meter in accordance with Tex-921-K. Ensure the accuracy of the meter is within 0.4% when using the asphalt meter for payment purposes. Ensure the accuracy of the meter is within 1.0% when used to measure component materials only and not for payment.

2.6. Liquid Asphalt Additive Meters. Provide a means to check the accuracy of meter output for asphalt primer, fluxing material, and liquid additives. Furnish a meter that reads in increments of 0.1 gal. or less. Verify accuracy of the meter in accordance with Tex-923-K. Ensure the accuracy of the meter within 5.0%.

2.7. Particulate Solid and Slurry Additive Meters. Provide a means to check the accuracy of meter output for particulate solids (such as hydrated lime or mineral filler) and slurries (such as hydrated lime slurry). Ensure the accuracy of the meter within 5.0%.

## 3. 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 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 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. 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 530
# Intersections, Driveways, and Turnouts

## 1. DESCRIPTION

Construct and pave intersections, driveways, and turnouts. Pave existing intersections, driveways, and turnouts.

Intersections are considered to be areas off the travel lanes and shoulders of the Contract highway on the intersecting highway on the state system. The intersecting on-system highway work will be paid for under this Item only when shown on the plans.

Driveways are defined as private (residential or commercial) and public (county road and city street) access areas off the travel lanes and shoulders.

Turnouts include but are not limited to mailbox and litter barrel widenings.

## 2. MATERIALS

Furnish materials that meet the following:

- Item 247, “Flexible Base”
- Item 260, “Lime Treatment (Road-Mixed)”
- Item 316, “Seal Coat”
- Item 334, “Hot-Mix Cold-Laid Asphalt Concrete Pavement”
- Item 340, “Dense-Graded Hot-Mix Asphalt (Small Quantity)”
- Item 360, “Concrete Pavement”
- Item 421, “Hydraulic Cement Concrete”
- Item 440, “Reinforcement for Concrete”

## 3. CONSTRUCTION

Construct and pave intersections, driveways, and turnouts, and pave existing intersections, driveways, and turnouts as shown on the plans or as directed. Place materials in accordance with construction Articles of pertinent Items. Provide uninterrupted access to adjacent property unless otherwise directed. Ensure that abrupt elevation changes in driveway or turnout areas that serve as sidewalks do not exceed 1/4 in. and that the sidewalk area cross slope does not exceed 2%. Ready-mix concrete and hand finishing will be permitted when concrete pavement is specified unless otherwise shown on the plans for intersections.

## 4. MEASUREMENT

This Item will be measured by the square yard of the final pavement 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 "Intersections," "Driveways," "Turnouts," "Intersections, Driveways, and Turnouts," or "Driveways and Turnouts" of the surface specified.

This price is full compensation for furnishing and operating equipment; excavation and embankment; base and pavement materials; and labor, materials, tools and incidentals. Drainage structures will be measured and paid for in accordance with the pertinent bid items.

# Item 531
# Sidewalks

## 1. DESCRIPTION

Construct hydraulic cement concrete sidewalks.

## 2. MATERIALS

Furnish materials conforming to the following:

- Item 360, “Concrete Pavement”
- Item 421, “Hydraulic Cement Concrete”
- Item 440, “Reinforcement for Concrete”

Use Class A concrete unless otherwise shown on the plans. Use Grade 8 course aggregate for extruded Class A concrete. Use other grades if approved.

## 3. CONSTRUCTION

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. Hand-tamp and sprinkle foundation when placement is directly on subgrade or foundation materials. Remove and dispose of existing concrete in accordance with Item 104, “Removing Concrete.” Provide a clean surface for concrete placement directly on the surface material or pavement.

Mix and place concrete in accordance with the pertinent Items. Hand-finishing is allowed for any method of construction. Finish exposed surfaces to a uniform transverse broom finish surface. Curb ramps must include a detectable warning surface and conform to details shown on the plans. Install joints as shown on the plans. Ensure that abrupt changes in sidewalk elevation do not exceed 1/4 in., sidewalk cross slope does not exceed 2%, curb ramp grade does not exceed 8.3%, and flares adjacent to the ramp do not exceed 10% slope. Ensure that the sidewalk depth and reinforcement are not less than the driveway cross-sectional details shown on the plans where a sidewalk crosses a concrete driveway.

Provide finished work with a well-compacted mass, a surface free from voids and honeycomb, and the required true-to-line shape and grade. Cure for at least 72 hr.

3.1. Conventionally Formed Concrete. Provide pre-molded or board expansion joints of the thickness shown on the plans for sidewalk section lengths greater than 8 ft. but less than 40 ft., unless otherwise directed. Terminate workday production at an expansion joint.

3.2. Extruded or Slipformed Concrete. Provide any additional surface finishing immediately after extrusion or slipforming as required on the plans. Construct joints at locations as shown on the plans or as directed.

## 4. MEASUREMENT

Sidewalks will be measured by the square yard of surface area. Curb ramps will be measured by the square yard of surface area or by each. A curb ramp consists of the ramp, landing, adjacent flares or side curb, and detectable warning surface as 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 price bid for "Concrete Sidewalks" of the depth specified and "Curb Ramps" of the type specified. This price is full compensation for surface preparation of sidewalk foundation; materials; removal and disposal of existing concrete; excavation, hauling and disposal of excavated material; drilling and doweling into existing concrete curb, sidewalk, and pavement; repair of adjacent street or pavement structure damaged by these operations; and equipment, labor, materials, tools, and incidentals.

Sidewalks that cross and connect to concrete driveways or turnouts will be measured and paid for in accordance with Item 530, "Intersections, Driveways, and Turnouts."

# Item 618
# Conduit

## 1. DESCRIPTION

Furnish and install conduit.

## 2. MATERIALS

Provide new materials that comply with the details shown on the plans, the requirements of this Item, and the pertinent requirements of the following Items:

- Item 400, "Excavation and Backfill for Structures"
- Item 476, "Jacking, Boring, or Tunneling Pipe or Box"

When specified on the plans, provide:

- rigid metal conduit (RMC);
- intermediate metal conduit (IMC);
- electrical metallic tubing (EMT);
- polyvinyl chloride (PVC) conduit;
- high density polyethylene (HDPE) conduit;
- liquidtight flexible metal conduit (LFMC); or
- liquidtight flexible nonmetallic conduit (LFNC).

Furnish conduit from new materials in accordance with DMS-11030, "Conduit."

Provide prequalified conduit from the Department's MPL. When required by the Engineer, notify the Department in writing of selected materials from the MPL intended for use on each project.

Provide other types of conduit not on the MPL that comply with the details shown on the plans and the NEC. Fabricate fittings such as junction boxes and expansion joints from a material similar to the connecting conduit, unless otherwise shown on the plans. Use watertight fittings. Do not use set screw and pressure-cast fittings. Steel compression fittings are permissible. When using HDPE conduit, provide fittings that are UL-listed as electrical conduit connectors or thermally fused using an electrically heated wound wire resistance welding method.

Use red 3-in. 4-mil polyethylene underground warning tape that continuously states "Caution Buried Electrical Line Below."

## 3. CONSTRUCTION

Perform work in accordance with the details shown on the plans and the requirements of this Item.

Use established industry and utility safety practices when installing conduit located near underground utilities. Consult with the appropriate utility company before beginning work.

Install conduit a minimum of 18 in. deep below finished grade unless otherwise shown on the plans. Meet the requirements of the NEC when installing conduit. Secure and support conduit placed for concrete encasement in such a manner that the alignment will not be disturbed during placement of the concrete. Cap ends of conduit and close box openings before concrete is placed.

Ream conduit to remove burrs and sharp edges. Use a standard conduit cutting die with a 3/4-in. taper per foot when conduit is threaded in the field. Fasten conduit placed on structures with conduit straps or hangers as shown on the plans or as directed. Fasten conduit within 3 ft. of each box or fitting and at other locations shown on the plans or as directed. Use metal conduit clamps that are galvanized malleable or stainless steel unless otherwise shown on the plans. Use 2-hole type clamps for 2-in. diameter or larger conduit.

Fit PVC and HDPE conduit terminations with bushings or bell ends. Fit metal conduit terminations with a grounding type bushing, except conduit used for duct cable casing that does not terminate in a ground box and is not exposed at any point. Conduit terminating in threaded bossed fittings does not need a bushing. Before installation of conductors or final acceptance, pull a properly sized mandrel or piston through the conduit to ensure that it is free from obstruction. Cap or plug empty conduit placed for future use.

Perform trench excavation and backfilling as shown on the plans or as directed, and in accordance with Item 400, "Excavation and Backfill for Structures." Excavation and backfilling will be subsidiary to the installation of the conduit.

Jack and bore as shown on the plans or as directed, and in accordance with Item 476, "Jacking, Boring, or Tunneling Pipe or Box."

Place warning tape approximately 10 in. above trenched conduit. Where existing surfacing is removed for placing conduit, repair by backfilling with material equal in composition and density to the surrounding areas and by replacing any removed surfacing, such as asphalt pavement or concrete riprap, with like material to equivalent condition. Mark conduit locations as directed.

## 4. MEASUREMENT

This Item will be measured by the foot of conduit.

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 "Conduit" of the type and size specified and the installation method specified as applicable. This price is full compensation for furnishing and installing conduit; hanging, strapping, jacking, boring, tunneling, trenching, and furnishing and placing backfill; encasing in steel or concrete; replacing pavement structure, sod, riprap, curbs, or other surface; marking location of conduit (when required); furnishing and installing fittings, junction boxes, and expansion joints; and materials, equipment, labor, tools, and incidentals.

Flexible conduit will not be paid for directly but will be subsidiary to pertinent Items. Unless otherwise shown on the plans, no payment will be allowed under this Item for conduit used on electrical services or in foundations.

# Item 620
# Electrical Conductors

## 1. DESCRIPTION

Furnish and install electrical conductors, except conductors specifically covered by other Items.

## 2. MATERIALS

Provide new materials that comply with the details shown on the plans and the requirements of this Item. Use stranded insulated conductors that are rated for 600 volts; approved for wet locations; and marked in accordance with UL, NEC, and CSA requirements. Furnish electrical conductors in accordance with DMS-11040, "Electrical Conductors."

Provide prequalified electrical conductors from the Department's MPL. When required by the Engineer, notify the Department in writing of selected materials from the MPL intended for use on each project.

Ensure all grounding conductors size 8 AWG and larger are stranded, except for the grounding electrode conductor at the electrical service, which will be a solid conductor.

Use white insulation for grounded (neutral) conductors, except grounded conductors size 4 AWG and larger may be black with white tape marking at every accessible location. Do not use white insulation or marking for any other conductor except control wiring specifically shown on the plans.

Ensure insulated grounding conductors are green except insulated grounding conductors size 4 AWG and larger may be black with green tape marking at every accessible location. Do not use green insulation or marking for any other conductor except control wiring specifically shown on the plans.

## 3. CONSTRUCTION

Perform work in accordance with the details shown on the plans and the requirements of this Item.

Splice conductors only in junction boxes, ground boxes, and transformer bases, and in poles and structures at the handholes. Splice as shown on the plans. Do not exceed the manufacturer's recommended pulling tension. Use lubricant as recommended by the manufacturer. Install conductors in accordance with the NEC.

Make insulation resistance tests on the conductors before making final connections, and ensure each continuous run of insulated conductor has a minimum DC resistance of 5 megohms when tested at 1,000 volts DC. The Engineer may require verification testing of all or part of the conductor system. The Engineer will witness these verification tests. Replace conductors exhibiting an insulation resistance of less than 5 megohms at no additional cost to the Department.

## 4. MEASUREMENT

This Item will be measured by the foot of each single conductor.

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 "Electrical Conductors" of the types and sizes specified. This price is full compensation for furnishing, installing, and testing electrical conductors; furnishing and installing breakaway connectors; and for materials, equipment, labor, tools, and incidentals, except:

- conductors used in connecting the components of electrical services will be paid for under Item 628, "Electrical Services";
- conductors inside of traffic signal pole assemblies will be paid for under this Item; and
- conductors used for internal wiring of equipment will not be paid for directly but will be subsidiary to pertinent Items.

# Item 624
# Ground Boxes

## 1. DESCRIPTION

- Installation. Construct, furnish, and install ground boxes complete with lids.
- Removal. Remove existing ground boxes.

## 2. MATERIALS

Provide new materials that comply with the details shown on the plans, the requirements of this Item, and the pertinent requirements of the following items:

- Item 420, “Concrete Substructures”
- Item 421, “Hydraulic Cement Concrete”
- Item 440, “Reinforcement for Concrete”
- Item 618, “Conduit”
- Item 620, “Electrical Conductors”

Provide fabricated precast polymer concrete ground boxes in accordance with DMS-11070, “Ground Boxes.” Provide prequalified ground boxes from the Department’s MPL. When required by the Engineer, notify the Department in writing of selected materials from the MPL intended for use on each project.

Provide other precast or cast-in-place ground boxes that comply with the details shown on the plans.

## 3. CONSTRUCTION

Perform work in accordance with the details shown on the plans and the requirements of this Item.

Use established industry and utility safety practices when installing or removing ground boxes located near underground utilities. Consult with the appropriate utility company before beginning work.

3.1. Installation. Fabricate and install ground boxes in accordance with the details, dimensions, and requirements shown on the plans. Install ground box to approved line and grade.

Construct precast and cast-in-place concrete ground boxes in accordance with Item 420, “Concrete Substructures,” and Item 440, “Reinforcement for Concrete.”

Construct concrete aprons as shown on the plans and in accordance with Item 440, “Reinforcement for Concrete.”

3.2. Removal. Remove existing ground boxes and concrete aprons to at least 6 in. below the conduit level. Uncover conduit to a sufficient distance so that 90 degree bends can be removed and conduit reconnected. Clean the conduit in accordance with Item 618, “Conduit.” Replace conduit within 5 ft. of the ground box. Remove old conductors and install new conductors as shown on the plans. Backfill area with material equal in composition and density to the surrounding area. Replace surfacing material with similar material to an equivalent condition.

## 4. MEASUREMENT

This Item will be measured by each ground box installed complete in place or each ground box removed.

## 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 "Ground Box" of the types and sizes specified and for "Remove Ground Box."

5.1. Installation. This price is full compensation for excavating and backfilling; constructing, furnishing, and installing ground boxes and concrete aprons; and material, equipment, labor, tools, and incidentals. All wiring connections required inside the ground box will be considered subsidiary to this bid item. Conduit will be paid for under Item 618, "Conduit." Electrical conductors will be paid for under Item 620, "Electrical Conductors."

5.2. Removal. This price is full compensation for removing and disassembling ground boxes and concrete aprons; excavating, backfilling, and surface placement; removing old conductors; disposal of unsalvageable materials; and materials, equipment, labor, tools, and incidentals. Cleaning of conduit is subsidiary to this Item. Conduit replaced within 5 ft. of the ground box will be subsidiary to this Item. Additional conduit will be paid for under Item 618, "Conduit." Installation of conductors will be paid for under Item 620, "Electrical Conductors."

# Item 628
# Electrical Services

## 1. DESCRIPTION

- Installation. Furnish and install electrical services.
- Relocation. Relocate existing electrical services.
- Removal. Remove existing electrical services.

## 2. MATERIALS

Provide materials that comply with the details shown on the plans, the requirements of this Item, and the pertinent requirements of the following Items:

- Item 441, "Steel Structures"
- Item 445, "Galvanizing"
- Item 618, "Conduit"
- Item 620, "Electrical Conductors"

For the installation of electrical services, use new materials that meet the requirements of the NEC, UL, CSA, and NEMA, and are in accordance with DMS-11080, "Electrical Services."

Provide prequalified electrical services prequalified from the Department's MPL. When required by the Engineer, notify the Department in writing of selected materials from the MPL intended for use on each project.

## 3. CONSTRUCTION

Perform work in accordance with the details shown on the plans and the requirements of this Item. Use established industry and utility safety practices when installing, relocating, or removing electrical services located near overhead or underground utilities. Consult with the appropriate utility company before beginning work.

3.1. Installation. Furnish and install electrical service equipment. Ensure components of the electrical service meet the requirements of the Electrical Detail Standards. Follow NEC and local utility company requirements when installing the electrical equipment. Coordinate the utility companies' work for providing service.

3.2. Relocation. Coordinate relocation with the appropriate utility company before beginning work. Remove existing electrical service according to "Removal" under this Item. Reinstall existing electrical service according to "Installation" of this Item. Replace or add circuit breakers as noted on the plans.

3.3. Removal. Coordinate removal with the appropriate utility company before beginning work. Before the removal of the electrical service, disconnect and isolate any existing electrical service equipment in accordance with the utility company's requirements.

Remove existing electrical service support a minimum of 2 ft. below finish grade unless otherwise shown on the plans. Repair the remaining hole by backfilling with material equal in composition and density to the surrounding area. Replace any surfacing such as asphalt pavement or concrete riprap with like material to equivalent condition.

Disconnect conductors and remove them from the conduit. Cut off all protruding conduit 6 in. below finished grade. Abandoned conduit need not be removed unless shown on the plans.

Reconnect conductors and conduit to be reused when shown on the plans. Make all splices in ground boxes unless otherwise shown on the plans.

Accept ownership of unsalvageable materials, and dispose of them in accordance with federal, state, and local regulations.

## 4. MEASUREMENT

This Item will be measured by each electrical service installed, relocated, or removed.

## 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 "Electrical Services" of the types specified, "Relocate Electrical Services," or "Remove Electrical Services."

5.1. Installation. This price is full compensation for paying all fees, permits, and other costs; making arrangements with the utility company for all work and materials provided by the utility company; furnishing, installing, and connecting all components including poles, service supports, foundations, anchor bolts, riprap, enclosures, switches, breakers, service conduit (from the service equipment including the elbow below ground), fittings, service conductors (from the service equipment including the elbow below ground),
brackets, bolts, hangers, hardware; and materials, equipment, labor, tools, and incidentals.

Costs for utility-owned power line extensions, connection charges, meter charges, consumption charges, and other charges will be paid for by the Department. The Department will reimburse the Contractor the amount billed by the utility plus an additional 5% of the invoice cost will be paid for labor, equipment, administrative costs, superintendence, and profit.

5.2. Relocation. This price is full compensation for disconnecting and isolating the existing electrical service; relocating the service supports; new service support foundation; backfilling holes; paying all fees, permits, and other costs; making arrangements with the utility company for all work and materials provided by the utility company; removing, disconnecting, installing, and connecting all components including poles, service supports, foundations, anchor bolts, riprap, enclosures, switches, breakers, service conduit (from the service equipment including the elbow below ground), fittings, service conductors (from the service equipment including the elbow below ground), brackets, bolts, hangers, hardware; and materials, equipment, labor, tools, and incidentals.

Costs for utility-owned power line extensions, connection charges, meter charges, consumption charges, and other charges will be paid for by the Department. The Department will reimburse the Contractor the amount billed by the utility plus an additional 5% of the invoice cost will be paid for labor, equipment, administrative costs, superintendence, and profit.

5.3. Removal. This price is full compensation for coordinating with the utility company to disconnect and isolate the electrical service; removing the service supports; backfilling holes; and materials, equipment, labor, tools, and incidentals.

# 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.

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 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 636, “Signs”

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

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.

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

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 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.

RPMs INSTALLATION RECORD FOR WRITTEN ACCEPTANCE

The 30-day performance period begins the day after 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.

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Contractor Signature _____ Date _____

Department Signature _____ Date _____

# 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 only.

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 680
# Highway Traffic Signals

## 1. DESCRIPTION

- **Installation.** Install highway traffic signals.
- **Removal.** Remove, store, and salvage traffic signals.

## 2. MATERIALS

Ensure electrical materials and construction methods conform to the current NEC and additional local utility requirements.

Furnish new materials. Ensure all materials and construction methods conform to the details shown on the plans, the requirements of this Item, and the pertinent requirements of the following Items:

- Item 636, "Signs"

Provide controller assemblies that meet the requirements of DMS-11170, "Fully Actuated, Solid-State Traffic Signal Controller Assembly," and the details shown on the plans.

Provide prequalified controller assemblies from the Department's MPL.

Provide flasher assemblies that meet the requirements of DMS-11160, "Flasher Controller Assembly," and the details shown on the plans.

Provide prequalified flasher assemblies from the Department's MPL.

Sampling and testing of traffic signal controller assemblies will be done in accordance with Tex-1170-T.

## 3. CONSTRUCTION

3.1. **Installation.** Install traffic signal controller foundations.

3.1.1. **Electrical Requirements.**

3.1.1.1. **Electrical Services.** Make arrangements for electrical services and install and supply materials not provided by the utility company as shown on the plans. Install 120-volt, single-phase, 60-Hz AC electrical service unless otherwise shown on the plans.

3.1.1.2. **Conduit.** Install conduit and fittings of the sizes and types shown on the plans. Conduit of larger diameter size than that shown on the plans may be used with no additional compensation, providing the same diameter size is used for the entire length of the conduit run. Extend conduit in concrete foundations 2 to 3 in. above the concrete. Seal the ends of each conduit with silicone caulking, or other approved sealant, after all cables and conductors are installed.

3.1.1.3. Wiring. Furnish stranded No. 12 AWG XHHW conductors. Install above-ground cables and conductors in rigid metal conduit, except for span wire suspended cables and conductors, drip loops, and electrical wiring inside signal poles unless otherwise shown on the plans. Make power entrances to ground-mounted controllers through underground conduit. Wire each signal installation to operate as shown on the plans.

Attach ends of wires to properly sized self-insulated solderless terminals. Attach terminals to the wires with a ratchet-type compression crimping tool properly sized to the wire. Place pre-numbered identification tags of plastic or tape around each wire adjacent to wire ends in the controller and signal pole terminal blocks.

Splices will not be permitted except as shown on the plans, unless each individual splice is approved in writing. Make all allowed splices watertight.

3.1.1.4. Grounding and Bonding. Ground and bond conductors in accordance with the NEC. Ensure the resistance from the grounded point of any equipment to the nearest ground rod is less than 1 ohm.

Install a continuous bare or green insulated copper wire (equipment ground) throughout the electrical system that is the same size as the neutral conductor, but a minimum No. 8 AWG. Connect the equipment ground to all metal conduit, signal poles, controller housing, electrical service ground, ground rods, and all other metal enclosures and raceways.

Provide copper wire bonding jumpers that are a minimum No. 8 AWG.

3.1.2. Controller Assemblies. Immediately before mounting the controller assembly on the foundation, apply a bead of silicone caulk to seal the cabinet base. Seal any space between conduit entering the controller and the foundation with silicone caulk.

Deliver the keys for the controller cabinets to the Engineer when the Contract is complete.

Place the instruction manual and wiring diagrams for all equipment in the controller cabinet, inside the controller cabinet.

3.1.3. Timber Poles. Furnish ANSI Class 2 timber poles other than for electrical services in accordance with details shown on the plans.

3.1.4. Preservation of Sod, Shrubbery, and Trees. Replace sod, shrubbery, and trees damaged during the Contract.

3.1.5. Removal and Replacement of Curbs and Walks. Obtain approval before cutting into or removing walks or curbs not shown on the plans to be removed or replaced. Restore any curbs or walks removed equivalent to original condition after work is completed, to the satisfaction of the Engineer.

3.1.6. Intersection Illumination. Install luminaires on signal poles as shown on the plans.

3.1.7. Signal Timing Plan. The traffic signal timing plan will be provided by the Department or local entity.

3.1.8. Test Period. Operate completed traffic signal installations continuously for at least 30 days in a satisfactory manner. If any Contractor-furnished equipment fails during the 30-day test period, repair or replace that equipment. This repair or replacement, except lamp replacement, will start a new 30-day test period.

Replace materials that are damaged or have failed before acceptance. Replace failed or damaged existing signal system components when caused by the Contractor. The Department will relieve the Contractor of maintenance responsibilities upon passing a 30-day performance test of the signal system and acceptance of the Contract.

3.2. Removal. Remove existing electrical services, pedestal poles, strain poles, mast arm pole assemblies, luminaires, signal heads, vehicle detector equipment, controllers, cables, and other accessories. Remove materials so damage does not occur. Remove and store items designated for reuse or salvage at locations shown on the plans or as directed.

Remove abandoned concrete foundations, including steel, to a point 2 ft. below final grade. Backfill holes with material equal in composition and density to the surrounding area. Replace surfacing material with similar material to an equivalent condition.

Accept ownership and dispose of unsalvageable materials in accordance with federal, state, and local regulations.

## 4. MEASUREMENT

This Item will be measured as each traffic signal installed or removed. A traffic signal is a signalized intersection controlled by a single traffic signal controller.

## 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 "Installation of Highway Traffic Signals" of the type (isolated, system, or flashing beacon) specified, or "Removing Traffic Signals."

5.1. Installation. This price is full compensation for furnishing, installing, and testing the completed installation, controller and associated equipment, controller foundations, luminaires, signs mounted on signal equipment, damping plates, timber poles, mounting hardware and steel wire strand; preservation and replacement of damaged sod, shrubbery and trees; removal and replacement of curbs and walks; and materials, equipment, labor, tools, and incidentals. The Department will pay for electrical energy consumed by the traffic signal.

New drilled shaft foundations for traffic signal poles will be paid for under Item 416, "Drilled Shaft Foundations." New conduit will be paid for under Item 618, "Conduit." New electrical conductors will be paid for under Item 620, "Electrical Conductors." 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 vehicle and pedestrian signal heads will be paid for under Item 682, "Vehicle and Pedestrian Signal Heads." New traffic signal cables will be paid for under Item 684, "Traffic Signal Cables." New traffic signal pole assemblies will be paid for under Item 686, "Traffic Signal Pole Assemblies (Steel)." New traffic signal detectors will be paid for under Item 688, "Pedestrian Detectors and Vehicle Loop Detectors."

5.2. Removal. This price is full compensation for removing the various traffic signal components; removing the foundations; disposal of unsalvageable materials; hauling; and materials, equipment, labor, tools, and incidentals.

# Item 682
# Vehicle and Pedestrian Signal Heads

## 1. DESCRIPTION

Furnish and install vehicle and pedestrian signal heads.

## 2. MATERIALS

Furnish only new materials.

2.1. Definitions.

- Back Plate. A thin strip of material extending outward from all sides of a signal head.
- LED Optical Unit. The LED lens and associated supporting parts in a signal section.
- Louver. A device mounted to the visor restricting signal face visibility.
- Signal Section. One housing case, housing door, visor, and optical unit.
- Signal Face. One section or an assembly of 2 or more sections facing one direction.
- Signal Head. A unidirectional face or a multidirectional assembly of faces, including back plates and louvers when required, attached at a common location on a support.

2.2. General. Provide vehicle signal heads in accordance with DMS-11121, "Twelve-Inch LED Traffic Signal Lamp Unit." Provide prequalified vehicle signal heads from the Department's MPL.

Provide pedestrian signal heads in accordance with DMS-11131, "Pedestrian LED Countdown Signal Modules." Provide prequalified pedestrian signal heads from the Department's MPL.

Supply either aluminum or polycarbonate signal head components of the same material and manufacturer for any one project.

Use galvanized steel, stainless steel, or dichromate sealed aluminum bolts, nuts, washers, lock washers, screws, and other assembly hardware. When dissimilar metals are used, ensure the metals are selected or insulated to prevent corrosion.

Use closed-cell silicone or closed-cell neoprene gaskets.

## 3. CONSTRUCTION

3.1. Assembly. Assemble individual signal sections in multi-section faces in accordance with the manufacturer's recommendations to form a rigid signal face. Assemble and mount signal heads as shown on the plans. Install louvers and back plates in accordance with the manufacturer's recommendations. Close any openings in an assembled signal head with a plug of the same material and color as the head.

Remove only the existing lens, reflector, and incandescent lamp when installing a retrofit replacement LED traffic signal or pedestrian signal lamp unit into an existing signal housing; fit the new unit securely in the housing door; and connect the new housing unit to the existing electrical wiring or terminal block by means of simple connectors.

3.2. Wiring. Wire each optical unit to the terminal block located in that signal section by means of solderless wire connectors or binding screws and spade lugs. Wire all sections of a multi-section signal face to the section terminal blocks in which the traffic signal cable is terminated. Maintain the color coding on leads from the

individual optical units throughout the signal head, except for the traffic signal cable. Use solderless wire connectors or binding screws and spade lugs for connections to terminal blocks. Use binding screws and spade lugs for field wiring.

## 4. MEASUREMENT

This Item will be measured by each vehicle signal section, pedestrian signal section, back plate, or louver.

## 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 “Pedestrian Signal Section,” “Vehicle Signal Section,” “Back Plate,” or “Louver,” of the types and sizes specified. This price is full compensation for furnishing, assembling, and installing the signal sections, back plates and louvers, and lenses and optics; mounting attachments; and materials, equipment, labor, tools, and incidentals.

# Item 684
# Traffic Signal Cables

## 1. DESCRIPTION

Furnish and install traffic signal cables.

## 2. MATERIALS

Provide polyethylene-jacketed multi-conductor cables in accordance with details shown on the plans. Individual conductors must be copper with polyethylene insulation rated for 600 volts. Furnish new materials. Provide traffic signal cables in accordance with DMS-11110, "Traffic Signal Cable."

2.1. Type A Cables. Use Type A cables meeting the requirements of IMSA 20-1 for underground conduit installation or aerial cable supported by a messenger.

2.2. Type B Cables. Use Type B cables meeting the requirements of IMSA 20-3 as the integral messenger cable for aerial installations.

2.3. Type C Cables. Use Type C cables meeting the requirements of IMSA 50-2 for loop detector lead-in installations consisting of 2 conductor shielded cable.

2.4. Types A and B Cable Materials. Provide the following materials for Type A and B cables:

- Use the size and number of conductors shown on the plans. Unless otherwise shown on the plans, use conductors consisting of 7 copper strands.
- Ensure color coding of conductors and sequence for cables are in compliance with Table 1. Base color is the insulation color. Tracer color is the colored stripe that is part of or firmly adhered to the insulation surface for the full length of the conductor.
- Ensure 2-conductor cable is of the round twisted type with fillers used where necessary to form a round cable.
- For cables with more than 2 conductors, ensure individual conductors are laid up symmetrically in layers with fillers used when necessary, to produce a uniform assembly of conductors with a firm, compact cylindrical core.
- Ensure fillers are a non-metallic, moisture-resistant, non-wicking material.
- Supply conductor assemblies covered with a wrapping of a moisture-resistant tape applied to overlap at least 10% of the tape width.
- Ensure the taped conductor assembly is covered with a tightly fitting black polyethylene jacket that is smooth and free from holes, splits, blisters, and any other imperfections.
- Supply cables that clearly show the name of the manufacturer and the IMSA specification number applied at approximate 2-ft. intervals to the outer surface of the jacket by indent printing.

Table 1
Conductor Color and Sequence for Cables

| Conductor No. | Base Color | Tracer Color |
|---|---|---|
| 1 | Black | |
| 2 | White | |
| 3 | Red | |
| 4 | Green | |
| 5 | Orange | |
| 6 | Blue | |
| 7 | White | Black |
| 8 | Red | Black |
| 9 | Green | Black |
| 10 | Orange | Black |
| 11 | Blue | Black |
| 12 | Black | White |
| 13 | Red | White |
| 14 | Green | White |
| 15 | Blue | White |
| 16 | Black | Red |
| 17 | White | Red |
| 18 | Orange | Red |
| 19 | Blue | Red |
| 20 | Red | Green |
| 21 | Orange | Green |

2.5. Additional Requirements for Type B Cable Materials. Additional material requirements particular to Type B cable are as follows:

- Ensure cables consisting of 5 or more conductors have a 0.25-in. nominal diameter messenger. For the messenger, use Class A galvanized Extra High Strength Steel Strand with 3 or 7 wires.
- A solid strand messenger with 0.134-in. diameter may be used for cables with less than 5 conductors.
- To provide corrosion protection, ensure the messenger strand is coated and the interstices are flooded with a rubber asphalt compound or equivalent.
- Ensure the integral messenger and conductors are enclosed in the jacket forming a cross-section similar to a figure 8.

2.6. Type C Cable Materials. Use the following materials for Type C cables:

- Unless otherwise shown on the plans, use No. 14 AWG insulated conductors with concentric stranding with black insulation on 1 of the 2 conductors and clear insulation on the other conductor. Ensure conductors have a minimum of 2 twists per foot within the cable.
- Use cables that have 100% shield coverage using aluminum bonded to a Mylar film. Ensure the drain wire is stranded tinned copper, 2 AWG sizes less than the conductor, and in continuous contact with the aluminum side of the shield material.
- Ensure the jacket is black polyethylene.
- Use cables that legibly show the name of the manufacturer and the IMSA specification number applied at approximate 2-ft. intervals on a tape under the outer jacket.

2.7. Sampling. The Engineer may take samples from each roll of each size of cable for establishing conformity to IMSA. The samples will be at least 3 ft. long. Replace any cable failing to meet IMSA requirements.

## 3. CONSTRUCTION

For each cable run in underground conduit, coil an extra 5 ft. of cable in each ground box.

Splices are not permitted in Type A and B cables unless shown on the plans, or approved in writing. Ensure splices are watertight.

Make splices between Type C cable and loop detector wires only in the ground box near the loop the cable is servicing. Use non-corrosive solder for splices. Ground the drain wire of Type C cable to earth ground only at the controller or detector cabinet. Ensure the resistance from the drain wire to the ground rod is less than 1 ohm.

Test the cables after installation and before any connection to the cables. Cables testing less than 50 megohms insulation resistance at 500 volts will be rejected.

## 4. MEASUREMENT

This Item will be measured by the foot of traffic signal cables.

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 "Traffic Signal Cables" of the types and sizes specified. This price is full compensation for furnishing and installing materials, and for equipment, labor, tools, and incidentals, except as shown below.

Cables inside traffic signal pole assemblies will be paid for under this Item.

Cables used for inside signal heads and controllers or coils in ground boxes, pole bases, and on span wires will not be paid for directly but will be subsidiary to pertinent Items.

# Item 686
# Traffic Signal Pole Assemblies (Steel)

## 1. DESCRIPTION

- **Installation**. Fabricate, furnish, and install steel traffic signal pole assemblies.
- **Relocation**. Remove and relocate existing steel traffic signal pole assemblies.

## 2. MATERIALS

Provide new materials that comply with the details shown on the plans, the requirements of this Item, and the pertinent requirements of the following Items:

- Item 416, "Drilled Shaft Foundations"
- Item 421, "Hydraulic Cement Concrete"
- Item 441, "Steel Structures"
- Item 442, "Metal for Structures"
- Item 445, "Galvanizing"

Furnish alloy steel or medium-strength mild steel anchor bolts in accordance with Section 449.2.1., "Bolts and Nuts," unless otherwise shown on the plans.

## 3. CONSTRUCTION

3.1. **Standard Design**. Fabricate poles assemblies in accordance with this Item to the designs shown on the plans. Alternate designs are not acceptable. Deviations that affect the basic structural behavior of the pole are considered to be alternate designs. For deviations that do not affect the basic structural behavior of the pole, electronically submit shop drawings in accordance with Item 441, "Steel Structures," to the Bridge Division for approval.

3.2. **Fabrication**. Fabricate and weld in accordance with Item 441, "Steel Structures," AWS D1.1, *Structural Welding Code—Steel*; and the requirements of this Item. Fabrication tolerances are given in Table 1.

Table 1
Fabrication Tolerances

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

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

Fabrication plants that produce steel traffic signal pole assemblies must be approved in accordance with DMS-7380, "Steel Non-Bridge Member Fabrication Plant Qualification." The Department maintains an MPL of approved traffic signal pole assembly fabrication plants.

Provide properly fitting components. Provide round or octagonal shafts for poles and mast arms tapered as shown on the plans. Fabricate mast arms straight in the unloaded condition unless otherwise shown on the plans. The Department will accept bolted slip joints overlapping by at least 1.5 diameters in mast arms 40 ft. and longer.

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

Treat welds with Ultrasonic Impact Treatment when shown on the plans after galvanization and with the dead load (actual or simulated) applied. Repair damaged galvanizing in accordance with Section 445.3.5., "Repairs."

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

Permanently mark, at a visible location when erected, pole base plates and mast arm mounting plates with the design wind speed.

Permanently mark, at a visible location when erected, pole base plates and fixed mast arm mounting plates with the fabrication plant's insignia or trademark. Place the mark on the pole base plate adjacent to the hand-hole access compartment.

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

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

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

Construct foundations for new traffic signal pole assemblies in accordance with Item 416, "Drilled Shaft Foundations," and the details shown on the plans. Orient anchor bolts as shown on the plans.

Erect structures after foundation concrete has attained its design strength as required on the plans and Item 421, "Hydraulic Cement Concrete."

After the traffic signal pole assembly is plumb and all nuts are tight, tack weld each anchor bolt nut in 2 places to its washer. Tack weld each washer to the base plate in 2 places. Never weld components to the bolt. Tack weld in accordance with Item 441, "Steel Structures." After tack welding, repair galvanizing damage on bolts, nuts, and washers in accordance with Section 445.3.5., "Repairs."

Do not grout between the base plate and the foundation.

3.4. Relocation. Disconnect and isolate traffic signal cables before removing the pole. Remove existing traffic signal pole assemblies as directed. Ensure the poles or attached components suffer no undue stress or damage. Signs, signal heads, mounting brackets, luminaires, etc., may be left on the poles. Repair or replace damaged components as directed.

Remove abandoned concrete foundations, including steel, to a point 2 ft. below final grade unless otherwise shown on the plans. Cut off and remove steel protruding from the remaining concrete. Backfill the hole with materials equal in composition and density to the surrounding area. Replace surfacing material with similar material to an equivalent condition.

Move existing pole assemblies to locations shown on the plans, or as directed. Construct foundations for relocated traffic signal pole assemblies in accordance with Item 416, "Drilled Shaft Foundations," and the details shown on the plans. Install existing pole assemblies on new foundations in accordance with Section 686.3.3., "Installation."

Accept ownership of unsalvageable materials and dispose of in accordance with federal, state, and local regulations.

## 4. MEASUREMENT

This Item will be measured by each traffic signal pole assembly installed 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 Traffic Signal Pole Assemblies (Steel)" of the types and sizes specified or "Relocate Traffic Signal Pole Assemblies (Steel)" of the types specified.

New drilled shaft foundations will be paid for under Item 416, "Drilled Shaft Foundations."

5.1. Installation. This price is full compensation for furnishing, fabricating, galvanizing, assembling, and erecting the pole upon a foundation; furnishing and erecting required mast arms and luminaire arms; furnishing and placing anchor bolts, nuts, washers, and templates; and materials, equipment, labor, tools, and incidentals.

5.2. Relocation. This price is full compensation for removing traffic signal pole assemblies; removing existing foundations; backfilling and surface placement; storing the components to be reused or salvaged; furnishing, fabricating, and installing required new components including anchor bolts, nuts, washers, and templates; placing and securing traffic signal pole assemblies on new foundations; furnishing and placing conduit, ground rods, and wiring; disposal of unsalvageable materials; loading and hauling; and materials, equipment, labor, tools, and incidentals.

# Item 688
# Pedestrian Detectors and Vehicle Loop Detectors

## 1. DESCRIPTION

Furnish and install traffic signal detectors.

## 2. MATERIALS

Provide new materials that comply with the details shown on the plans, the requirements of this Item, and the pertinent requirements of the following Items:

- Item 618, "Conduit"
- Item 624, "Ground Boxes"
- Item 682, "Vehicle and Pedestrian Signal Heads"
- Item 684, "Traffic Signal Cables"

2.1. **Pedestrian Detectors.** Supply housing or an adapter (saddle) that conforms to the pole shape, fitting flush to ensure a rigid installation. Supply adapters of the same material and construction as the housing. Supply push-button switches that have single-pole, single-throw contacts and screw-type terminals and have a design life of at least 1 million operations.

Ensure the internal components provide a push-button with normal open contacts, and include all electrical and mechanical parts required for operation. Ensure the push-button assembly is weather-tight and tamperproof, is designed to prevent an electrical shock under any weather condition, and has provisions for grounding in accordance with the NEC.

2.1.1. **Standard Pedestrian Detectors.** Provide a 2-piece cast aluminum housing unit consisting of a base housing and a removable cover. Provide threaded holes for 0.5-in conduit in the housing for any necessary conduit attachment.

Ensure the manufacturer's name or trademark is located on the housing.

2.1.2. **Accessible Pedestrian Signals (APS).** Provide accessible pedestrian detectors in accordance with DMS-11132, "Accessible Pedestrian Signals (APS)."

2.2. **Vehicle Loop Detectors.** Use stranded copper No. 14 AWG XHHW cross-linked-thermosetting-polyethylene-insulated conductor rated for 600 volts AC for vehicle detector loop wire unless otherwise shown on the plans. Ensure each length of wire shows the name or trademark of the manufacturer, insulation voltage rating, wire gauge, and insulation type at approximate 2-ft. intervals on the insulation surface.

When shown on the plans, use flexible vinyl or polyethylene tubing with 0.184 in. minimum inside diameter, 0.031 in. minimum wall thickness, 0.26 in. maximum outside diameter, and a smooth bore. Use tubing that does not adhere to the loop wire in any way and is capable of resisting deterioration from oils, solvents, and temperatures up to 212°F. Use tubing that is abrasion-resistant and remains flexible from –22°F to 212°F. Use orange or red tubing unless otherwise shown on the plans.

Use sealant for the vehicle detector loops in accordance with DMS-6340, "Vehicle Loop Wire Sealant."

## 3. CONSTRUCTION

3.1. **Pedestrian Detectors.**

3.1.1. **Push-Button Unit**. Meet the requirements of the TMUTCD when installing push-buttons. Wire the push-button according to manufacturer's installation instructions. Close unused housing openings with a weather-tight closure painted to match the housing. Verify that each button is communicating and fully functional.

Do not use terminal connections or splice wire leads except at approved locations. All allowed splices must be watertight.

Attach wires to terminal posts with solderless terminals unless otherwise advised by manufacturer's recommendations. Attach terminals to the wires with a ratchet-type compression crimping tool properly sized to the wire.

Mount a pedestrian push button sign near each push button as shown on the plans.

For installations where APS buttons are placed less than 10 ft. apart from one another, program the appropriate speech walk message (include the name of the appropriate street in the message) for these buttons. When 2 APS buttons are installed on the same pole ensure that the APS buttons are insulated to eliminate vibrations from traveling to the other button.

3.1.2. **Controller Unit**. If a controller unit is required by the plans, integrate the pedestrian controller unit into the traffic signal controller cabinet assembly.

3.2. **Vehicle Loop Detectors**. Provide the loop location, configuration, wire color, and number of turns shown on the plans. Loops may be adjusted by the Engineer to fit field conditions.

3.2.1. **Saw-Cuts**. Cut the pavement with a concrete saw to form neat lines. Do not exceed 1 in. depth on concrete bridge slab saw-cuts. Cut all other saw-cuts deep enough to provide a minimum of 1 in. depth of sealant over the wire. Make a separate saw-cut from each loop to the edge of the pavement unless otherwise shown on the plans. Ensure the cut is clean and dry when the wire and sealant are placed.

3.2.2. **Conduit**. Place conduit between the pavement and ground box as shown on the plans.

3.2.3. **Loop Wire Color**. Use the following color code unless otherwise shown on the plans. Use white for the first loop on the right followed by black, orange, green, brown, and blue. Use the same color for all loops in the same lane. Loops installed in multi-lanes will have the same color code in the order the loops are installed. When facing the same direction that traffic flows, the color code will read from right to left for all lanes carrying traffic in that direction. If traffic moves in 2 directions, the color code will be repeated for the other direction of traffic.

3.2.4. **Loop Wire Installation**. When shown on the plans, place the loop wire in a flexible vinyl or polyethylene tubing in accordance with Article 688.2., "Materials." The loop wire color requirements do not apply to wires in tubing.

Twist the wire from the loop to the ground box a minimum of 5 turns per foot. When only one pair of wires is in a saw-cut, it need not be twisted while in the saw-cut. Do not splice loop wire in the loop or in the run to the ground box.

Hold the loop wire in place every 2 ft. with strips of rubber, neoprene flexible tubing, or polyethylene foam sealant approximately 1 in. long. Leave these strips in place and fill the slot with loop sealant.

Splice the loop lead-in cable and loop detector wires only in the ground box near the loop it is serving. Use non-corrosive solder for splices and ensure the splice is watertight. Ground the drain wire of the loop lead-in

cable to earth ground only at the controller or detector cabinet. Ensure the resistance from the drain wire to the ground rod is less than 1 ohm.

## 4. MEASUREMENT

This Item will be measured by the foot of saw-cut containing loop wire and each pedestrian push-button and controller unit.

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 "Vehicle Loop Detectors" of the type specified, "Pedestrian Detector Push-button Units" of the type specified or "Pedestrian Detector Controller Unit." This price is full compensation for furnishing, installing, and testing the detectors, detector controller units, including detector configuration devices or software (when applicable); saw-cutting, excavation, backfill, sealant, and sealant placement; pavement repair associated with saw-cutting; and materials, equipment, labor, tools, and incidentals, except as follows.

The conduit and loop wire from the edge of pavement to the ground box used for the vehicle loop detectors will not be measured or paid for directly but will be subsidiary to this Item.

New ground boxes will be paid for under Item 624, "Ground Boxes." New loop lead-in cable will be paid for under Item 684, "Traffic Signal Cables."

# Item 690
# Maintenance of Traffic Signals

## 1. DESCRIPTION

Furnish, install, modify, repair, replace, or remove components of a traffic signal:

## 2. MATERIALS

The Department will only furnish traffic signal poles, mast arms, and controllers that become part of the final installation, unless otherwise noted on the plans. Submit a materials list to the Engineer for all poles, mast arms, and controllers needed. Pick up materials at the locations and times shown on the plans. Designate in writing the persons authorized to pick up the materials.

Assume responsibility for all materials furnished by the Department. Use materials furnished by the Department for this Contract only. Return unused or removed materials deemed salvageable by the Engineer to the Department upon completion of the work and before final payment at location shown on the plans or as directed. Dispose of materials deemed unsalvageable by the Engineer, in accordance with federal, state, and local regulations. When materials are required to be furnished by the Contractor, meet the Materials Article requirements of the pertinent Item.

## 3. EQUIPMENT

Use equipment that includes, but is not limited to:

- an aerial device capable of reaching overhead work,
- trenching machine,
- boring machine,
- concrete saw, and
- digger-boom truck.

Use only equipment, tools, and machinery in good repair and operating condition. Repair or replace any equipment that, in the opinion of the Engineer, may affect the quality of work or safety.

## 4. WORK METHODS

Conform to the NEC, local utility requirements, requirements of this Item, and pertinent requirements of the following Items:

- Item 416, “Drilled Shaft Foundations”
- Item 421, “Hydraulic Cement Concrete”
- Item 476, “Jacking, Boring, or Tunneling Pipe or Box”
- Item 618, “Conduit”
- Item 620, “Electrical Conductors”
- Item 624, “Ground Boxes”
- Item 628, “Electrical Services”
- Item 636, “Signs”

- Item 680, “Highway Traffic Signals”
- Item 682, “Vehicle and Pedestrian Signal Heads”
- Item 684, “Traffic Signal Cables”
- Item 686, “Traffic Signal Pole Assemblies (Steel)”
- Item 688, “Pedestrian Detectors and Vehicle Loop Detectors”

Perform the following work as directed:

4.1. Conduit. Install, replace, remove, or modify conduits in accordance with Item 618, “Conduit”; as shown on the plans; or as directed. Use 90° “sweep” type elbow on conduits entering a ground box.

4.2. Foundations. Install, replace, or remove foundations for traffic signal pole, pedestal pole, and ground mount controller cabinets in accordance with Item 416, “Drilled Shaft Foundations”.

4.3. Concrete. Install concrete in accordance with Item 421, “Hydraulic Cement Concrete.”

4.4. Ground Boxes. Install, repair, replace, remove, or modify ground boxes in accordance with Item 624, “Ground Boxes”; as shown on the plans; or as directed.

4.5. Vehicle and Pedestrian Detectors. Install, repair, replace, remove, or modify pedestrian push buttons and vehicle loop detectors in accordance with Item 688, “Pedestrian Detectors and Vehicle Loop Detectors”; as shown on the plans; or as directed.

4.6. Electrical Service. Install, repair, replace, remove, or modify an electrical service assembly in accordance with Item 628, “Electrical Services”; as shown on the plans; or as directed. Mount any or all of the following on an electrical service support assembly: conduit, weather head, load center, meter base, lightning protection, wiring, and associated hardware.

4.7. Signal Pole. Install, repair, replace, remove, or modify signal poles in accordance with pertinent Items, as shown on the plans, or as directed. Comply with Item 686, “Traffic Signal Pole Assemblies (Steel),” for steel poles with concrete foundations. Remove timber poles and anchors completely, to 24 in. below ground level, or as directed. Remove concrete foundations to 24 in. below ground level, or as directed.

4.8. Down Guy. Install, replace, remove, or modify down guy with guard or down guy with anchor and guard.

4.9. Steel Wire Strand. Install, replace, or remove steel wire strand as shown on the plans; or as directed. Attach span wire on timber poles using a 5/8-in. straight thimble-eye bolt. Attach span wire on metal poles using at least 2 turns of wire around the pole. Place and properly tighten the 3-bolt clamp as near as possible to the pole.

4.10. Luminaire Head and Mast Arm. Install, replace, remove, or modify luminaire heads, arms, bulbs, photocells, and hardware on timber or steel signal poles. Install material using manufacturer’s specifications. Fuse luminaires individually in the signal pole hand-hole. Install a separate cable from the breaker load panel to each luminaire.

4.11. Signal Head Assembly. Install, repair, replace, remove, or modify pedestrian signal heads or vehicle signal head assemblies in accordance with Item 682, "Vehicle and Pedestrian Signal Heads"; as shown on the plans; or as directed. Mount signal heads by a span wire hanger clamp, bracket arm assembly, or mast arm bracket assembly. Signal head assemblies consist of 1 to 12 signal sections. Install signal heads as shown on the plans, or as directed.

Assemble the signal heads with backplates, louvers, and brackets as needed. Mount all signal heads at the same elevation. Install signal head perpendicular to the travel lane it controls. Plumb all signal heads vertically and horizontally.

4.12. Traffic Signal Controller Cabinet, Ground Mount. Install, repair, replace, remove, or modify ground-mounted cabinet. Plumb and tighten the cabinet. Apply silicone sealant around the base of the cabinet. Coil all cabling that enters the cabinet neatly on the cabinet floor. Mark and terminate each cable as shown on the plans, or as directed.

4.13. Traffic Signal Controller Cabinet, Pole Mount. Install, repair, replace, remove, or modify pole-mounted cabinet. Plumb and tighten the cabinet. Coil all cabling that enters the cabinet neatly on the cabinet floor. Mark and terminate each cable as shown on the plans, or as directed.

4.14. Flashing Beacon Controller Cabinet. Install, repair, replace, remove, or modify flasher cabinet. Plumb and tighten the cabinet. Coil all cabling that enters the cabinet neatly on the cabinet floor. Mark and terminate each cable as shown on the plans, or as directed.

4.15. Cables. Install, repair, replace, remove, or modify signal, loop lead-in, electrical, communication, or illumination cables in conduits or along messenger cables in accordance with Item 620, "Electrical Conductors"; in accordance with Item 684, "Traffic Signal Cables"; as shown on the plans; or as directed.

Attach aerial cable at 1-ft. intervals using approved cable ties along a messenger span cable. Install a drip loop with at least 2 turns at each pole, signal head, and weather head.

Label each cable brought into the controller cabinet. Coil 5 ft. of cable neatly on the traffic signal controller cabinet floor for each cable.

Install solderless pressure connectors that meet the requirements of the NEC for all wires attached to terminal posts. Use a ratchet-type full-circle crimper for insulated terminals to provide a solderless pressure connector.

4.16. Sealing. Install, repair, replace, remove, or modify sealant in detector saw slots, at the open end of all conduits terminated at the roadway edge, and in ground boxes. Apply sealant as shown on the plans or as directed.

4.17. Salvage Operations. Remove traffic signal when no replacement is required. Return unused or removed material deemed salvageable by the Engineer to the Department. Dispose of all other material.

4.18. Signal-Related Signs. Install, repair, replace, remove, or modify small post-mounted or overhead signs.

4.19. Curbs, Ramps, and Sidewalks. Install, repair, replace, remove, or modify curbs, ramps, and sidewalks. Secure permission to install traffic signal items before cutting into or removing curbs, ramps, and sidewalks. Replace all curbs, ramps, and sidewalks as shown on the plans. Install pedestrian access ramps as shown on the plans.

4.20. Protection of Utilities. Locate and protect all public lines and utility customer service lines in the work area. Notify the utility company and locate and mark, uncover, or otherwise protect all such lines in the construction area. Obtain information on the location and grade of water, sewer, gas, telephone, electric lines, and other utilities in the work area from the utility company. This information does not relieve the Contractor of responsibility for protecting utilities.

Reimburse the utility line owner for expenses or costs (including fines that may be levied against the utility company) that may result from unauthorized or accidental damage to any utility lines in work area.

4.21. Preservation of Sod, Shrubbery, and Trees. Preserve all sod, shrubbery, and trees at the site during the Contract. Obtain permission to remove any sod, shrubbery, or tree branches. Preserve and restore sod and shrubbery into their original position. Replace damaged sod or shrubbery at the Contractor's expense.

4.22. PVC Weatherproof Enclosures. Install, remove, or replace 12 × 12 × 6-in. PVC weatherproof enclosure at locations shown on the plans or as directed. Only use enclosure for reconnecting or terminating traffic signal cables at the top of a timber or steel strain pole which has been replaced or reinstalled due to accidental knock down.

4.23. LED Lamp Unit. Install, replace, or remove LED optical unit in accordance with Item 682, "Vehicle and Pedestrian Signal Heads"; as shown on the plans; or as directed.

4.24. Spread Spectrum Radio Antennas. Replace, repair, or install spread spectrum radio antenna in accordance with Special Specification, "Spread Spectrum Radios for Traffic Signals"; as shown on the plan; or as directed.

4.25. Video Imaging Vehicle Detection System (VIVDS). Install, repair, replace, remove, or modify VIVDS in accordance with Special Specification, "Video Imaging Vehicle Detection System," as shown on the plans, or as directed.

## 5. MEASUREMENT

Measurement will be as follows:

5.1. Removal of Conduit. By the foot of conduit.

5.2. Installation of Conduit by Trenching. By the foot of the trench containing conduit, regardless of the size of conduit.

5.3. Installation of Conduit by Jacking or Boring. By the foot of road bore made. Pits for jacking or boring are subsidiary to this Item.

5.4. Installation of Vehicle Detectors. By the foot of saw-cut containing detector wire.

5.5. Removal, Replacement, or Installation of Ground Boxes. By each box removed, replaced, or installed, regardless of the type of box. A concrete apron around the box will be considered subsidiary to this Item.

5.6. Removal, Replacement, or Installation of Cables. By the foot of traffic signal cables removed, replaced, or installed, except measurement will not be made for cable inside signal heads and controllers or cable coiled in ground boxes, in pole bases, and on span wires.

5.7. Installation of Duct Cables. By the foot of trench containing duct cable.

5.8. Removal, Replacement, or Installation of Cables by Messenger Cable. By the foot removed, replaced, or installed.

5.9. Removal, Replacement, or Installation of Span Cable Assembly. By the foot of span removed, replaced, or installed. A span is defined as the distance from one pole to the next pole.

5.10. Replacement or Installation of Electrical Service. By each electrical service replaced or installed. The removal of the existing assembly will be considered subsidiary to this Item.

5.11. Removal, Replacement, or Installation of Timber Poles. By each timber pole removed, replaced, or installed. Attachment of required hardware is subsidiary to this Item.

5.12. Removal, Replacement, or Installation of Signal Head Assemblies. By each head removed, replaced, or installed. Assembly and wiring are subsidiary to this Item.

5.13. Removal, Replacement, or Installation of Signal Related Signs. By each sign assembly removed, replaced, or installed.

5.14. Removal, Replacement, or Installation of Pedestrian Push Buttons. By each push button removed, replaced, or installed.

5.15. Removal, Replacement, or Installation of Traffic Signal Pole Foundations. By the foot, of the type of foundation removed, replaced, or installed.

5.16. Installation of Foundations for Ground Mount or Pole Mount Cabinets. By each foundation installed.

5.17. Removal, Replacement, or Installation of Controller Cabinet, Ground Mount. By each cabinet removed, replaced, or installed.

5.18. Removal, Replacement, or Installation of Controller Cabinet, Pole Mount. By each cabinet removed, replaced, or installed.

5.19. Removal, Replacement, or Installation of Flasher Cabinet. By each cabinet removed, replaced, or installed.

5.20. Installation of Foundations for Roadside Flashing Beacon Assemblies. By each foundation installed.

5.21. Removal, Replacement, or Installation of Roadside Flashing Beacon Assemblies. By each assembly removed, replaced, or installed.

5.22. Removal, Replacement, or Installation of Signal Pole Assemblies. By each assembly, according to the type of pole assembly removed, replaced, or installed. Wiring in the pole and hardware is subsidiary to this Item.

5.23. Removal, Replacement, or Installation of Curbs. By the foot removed, replaced, or installed.

5.24. Removal, Replacement, or Installation of Pedestrian Ramps. By each ramp removed, replaced, or installed.

5.25. Removal, Replacement, or Installation of Sidewalks. By the square foot removed, replaced, or installed.

5.26. Removal of Concrete Foundations. By each foundation removed.

5.27. Removal, Replacement, or Installation of Luminaire Heads. By each luminaire head removed, replaced, or installed.

5.28. Removal, Replacement, or Installation of Luminaire Mast Arms. By each mast arm removed, replaced, or installed.

5.29. Removal, Replacement, or Installation of Down Guy with Guard. By each down guy with guard removed, replaced, or installed.

5.30. Removal, Replacement, or Installation of Down Guy with Guard and Anchor. By each down guy with guard and anchor removed, replaced, or installed.

5.31. **Remove and Salvage Traffic Signals**. By each signalized intersection salvaged. A signalized intersection is a group of traffic signals operated by a single controller.

5.32. **Removal, Replacement, or Installation of 12 × 12 × 6-in. PVC Weatherproof Enclosure**. By each PVC weatherproof enclosure removed, replaced, or installed.

5.33. **Removal, Replacement, or Installation of LED Lamp Unit**. By each LED lamp unit removed, replaced, or installed.

5.34. **Removal, Replacement, or Installation of Spread Spectrum Radio Antennas**. By each radio antenna removed, replaced, or installed.

5.35. **Removal, Replacement, or Installation of Video Imaging Vehicle Detection System (VIVDS)**. By each camera assembly removed, replaced, or installed.

## 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 prices for the various designations. This price is full compensation for furnishing all materials, equipment, labor, fines, tools, and incidentals. The Department will pay for electrical energy consumed by the traffic signal.

Wiring in the pole; splices; backfill (soil or concrete); sealing of conduit ends and loop detector saw slots; installation of loop wire and PVC for encased loops; protection of utilities; and preservation of sod, shrubbery, and trees will not be measured or paid for directly but will be subsidiary to pertinent Items.

# Item 734
# Litter Removal

## 1. DESCRIPTION

Remove and dispose of litter, including objects not part of the highway facility, such as trash, garbage, scrap metal, paper, wood, plastic, glass products, animal remains, rubber products, tires, auto parts, furniture, mattresses, household appliances, and large bulky items.

## 2. MATERIALS

Furnish bags and containers.

## 3. EQUIPMENT

Provide equipment and tools. Provide highly visible omni-directional amber flashing warning lights on work vehicles. Provide equipment that prevents the accumulated debris from being strewn along the roadway during transport.

## 4. WORK METHODS

Remove bagged litter on the same day it is collected. Notify the Department for removal of dead animals larger than 150 lb. or hazardous materials. Dispose of litter off the right of way in accordance with federal, state, and local regulations. Perform litter removal and disposal according to the following types.

4.1. Litter. Remove and dispose of litter from the right of way, including shoulders but excluding the traveled lanes and shoulders next to barriers, to the limits shown on the plans.

4.2. Spot Litter. Work requests are made on a callout basis. Begin removing litter within 3 hr. of notification, unless otherwise shown on the plans.

## 5. MEASUREMENT

This Item will be measured as follows:

5.1. Litter. By the cycle or acre.

5.2. Spot Litter. By the acre. The minimum quantity per callout is 3 acres, unless otherwise 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 prices bid for “Litter Removal” or “Litter Removal (Spot).” This price is full compensation for collecting, hauling, and disposing of litter; and for equipment, labor, materials, tools, and incidentals.

# 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. Aggregate Removal. Clean and remove aggregate from designated areas following adverse weather conditions.

3.6. 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.

3.7. 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.

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. Aggregate Removal. By the roadbed mile.

4.6. Spot. By the roadbed mile. The minimum quantity per callout is 1 roadbed mile, unless otherwise shown on the plans.

4.7. 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 specified type. 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.

**TxDOT**
**SPECIAL SPECIFICATION**

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# Special Specification 6002
# Video Imaging Vehicle Detection System

## 1. DESCRIPTION

Install a Video Imaging Vehicle Detection System (VIVDS) that monitors vehicles on a roadway via processing of video images and provides detector outputs to a traffic controller or similar device.

A VIVDS configuration for a single intersection will consist of variable focal length cameras, VIVDS card rack processor system, and all associated equipment required to setup and operate in a field environment, including a video monitor and laptop (if required), connectors, and camera mounting hardware.

The system is composed of these principal items: the cameras, the field communications link between the camera and the VIVDS processor unit, and the VIVDS processor unit along with a PC, video monitor, or associated equipment required to setup the VIVDS and central control software to communicate to the VIVDS processor.

The VIVDS Card Rack Processor must be either NEMA TS 2 TYPE 1 or TYPE 2. TYPE 2 must have RS 485 SDLC.

## 2. DEFINITIONS

2.1. **VIVDS Processor Unit**. The electronic unit that converts the video image provided by the cameras, generates vehicle detections for defined zones, and collects vehicular data as specified.

2.2. **VIVDS Processor System**. One or more VIVDS processor modular units required to handle the number of camera inputs.

2.3. **Central Control**. A remotely located control center, which communicates with the VIVDS. The VIVDS operator at the central control has the ability to monitor the operation and modify detector placement and configuration parameters. The equipment that constitutes central control is comprised of a workstation microcomputer along with the associated peripherals as described in this Special Specification.

2.4. **Field Setup Computer**. A portable microcomputer used to set up and monitor the operation of the VIVDS processor unit. If required to interface with the VIVDS processor unit, the field setup computer with the associated peripherals described in this Special Specification and a video monitor, also described in this Special Specification, must be supplied as part of the VIVDS.

2.5. **Field Communications Link**. The communications connection between the camera and the VIVDS processor unit. The primary communications link media may be coaxial cable or fiber optic cable.

2.6. **Remote Communications Link**. The communications connection between the VIVDS processor unit and the central control.

2.7. **Camera Assembly**. The complete camera or optical device assembly used to collect the visual image. The camera assembly consists of a charged coupled device (CCD) camera, environmental enclosure, sun shield, temperature control mechanism, and all necessary mounting hardware.

2.8. **Occlusion**. The phenomenon when a vehicle passes through the detection zone but the view from the sensor is obstructed by another vehicle. This type of occlusion results in the vehicle not being detected by the sensor or when a vehicle in one lane passes through the detection zone of an adjacent lane. This type of occlusion can result in the same vehicle being counted in more than one lane.

2.9. **Detection Zone**. The detection zone is a line or area selected through the VIVDS processor unit that when occupied by a vehicle, sends a vehicle detection to the traffic controller or freeway management system.

2.10. **Detection Accuracy**. The measure of the basic operation of a detection system (shows detection when a vehicle is in the detection zone and shows no detection when there is not a vehicle in the detection zone).

2.11. **Live Video**. Video being viewed or processed at 30 frames per second.

2.12. **Lux**. The measure of light intensity at which a camera may operate. A unit of illumination equal to one lumen per square meter or to the illumination of a surface uniformly one meter distant from a point source of one candle.

2.13. **Video Monitor**. As a minimum must be a 9-in. black and white monitor with BNC connectors for video in and out.

## 3. FUNCTIONAL CAPABILITIES

The system software must be able to detect either approaching or departing vehicles in multiple traffic lanes. A minimum of 4 detector outputs per video processor module card and each card must have a minimum of 24 detection zones. Each zone and output must be user definable through interactive graphics by placing lines or boxes in an image on a video or VGA monitor. The user must be able to redefine previously defined detection zones.

The VIVDS must provide real time vehicle detection (within 112 milliseconds (ms) of vehicle arrival).

The VIVDS processor unit must be capable of simultaneously processing information from various video sources, including CCTV video image sensors and video tape players. The video sources may be, but are not required to be, synchronized or line-locked. The video must be processed at a rate of 30 times per second by the VIVDS processor unit.

The system must be able to detect the presence of vehicles in a minimum of 12 detection zones within the combined field of view of all cameras (a minimum of 12 detection zones per camera input to the VIVDS processor unit).

Provide detection zones that are sensitive to the direction of vehicle travel. The direction to be detected by each detection zone must be user programmable.

The VIVDS processor unit must compensate for minor camera movement (up to 2% of the field of view at 400 ft.) without falsely detecting vehicles. The camera movement must be measured on the unprocessed video input to the VIVDS processor unit.

The camera must operate while directly connected to VIVDS Processor Unit.

Once the detector configuration has been downloaded or saved into the VIVDS processor unit, the video detection system must operate with the monitoring equipment (monitor or laptop) disconnected or online.

When the monitoring equipment is directly connected to the VIVDS processor unit, it must be possible to view vehicle detections in real time as they occur on the field setup computer's color VGA display or the video monitor.

## 4. VEHICLE DETECTION

4.1. **Detection Zone Placement**. The video detection system must provide flexible detection zone placement anywhere within the combined field of view of the image sensors. Preferred presence detector configurations must be lines or boxes placed across lanes of traffic or lines placed in line with lanes of traffic. A single detector must be able to replace one or more conventional detector loops. Detection zones must be able to

be fully overlapped. In addition, detection zones must have the capability of implementing “AND” and “OR” logical functions including presence, extension and delay timing. These logical functions may be excluded if provisions are made to bring each detector separately into the controller and the controller can provide these functions.

4.2. **Detection Zone Programming**. Placement of detection zones must be by means of a graphical interface using the video image of the roadway. The monitor must show images of the detection zones superimposed on the video image of traffic while the VIVDS processor is running.

The detection zones must be created by using the mouse or keypad to draw detection zones on the monitor. The detection zones must be capable of being sized, shaped and overlapped to provide optimal road coverage and detection. It must be possible to upload detector configurations to the VIVDS processor unit and to retrieve the detector configuration that is currently running in the VIVDS processor unit.

The mouse or keypad must be used to edit previously defined detector configurations so as to fine tune the detection zone placement size and shape. Once a detection configuration has been created, the system must provide a graphic display of the new configuration on its monitor. While this fine-tuning is being done, the detection must continue to operate from the detector configuration that is currently called.

When a vehicle occupies a detection zone, the detection zone on the live video must indicate the presence of a vehicle, thereby verifying proper operation of the detection system. With the absence of video, the card must have an LED that will indicate proper operation of the detection zones.

Provide detection zones that are sensitive to the direction of vehicle travel. The direction to be detected by each detection zone must be user programmable. The vehicle detection zone should not activate if a vehicle traveling any direction other than the one specified for detection occupies the detection zone. Cross-street and wrong way traffic should not cause a detection.

4.3. **Design Field of View**. The video detection system must reliably detect vehicle presence in the design field of view. The design field of view must be defined as the sensor view when the image sensor is mounted 24 ft. or higher above the roadway, when the camera is adjacent (within 15 ft.) to the edge of the nearest vehicle travel lane, and when the length of the detection area is not greater than 10 times the mounting height of the image sensor. Within this design field of view, the VIVDS processor unit must be capable of setting up a single detection zone for point detection (equivalent to the operation of a 6 ft. × 6 ft. inductive loop). A single camera, placed at the proper mounting height with the proper lens, must be able to monitor up to and including 5 traffic lanes simultaneously.

4.4. **Detection Performance**. Detection accuracy of the video detection system must be comparable to properly operating inductive loops. Detection accuracy must include the presence of any vehicle in the defined detection zone regardless of the lane, which the vehicle is occupying. Occlusion produced by vehicles in the same or adjacent lanes must not be considered a failure of the VIVDS processor unit, but a limitation of the camera placement. Detection accuracy (a minimum of 95%) must be enforced for the entire design field of view on a lane by lane and on a time period basis. When specified on the plans, furnish up to 24 continuous hours of recorded video of all installed intersection cameras within the 30 day test period for verification of proper camera placement, field of view, focus, detection zone placement, processor setup and operation. The video from each camera must show vehicle detections for all zones.

4.5. **Equipment Failure**. Either camera or VIVDS processor unit must result in constant vehicle detection on affected detection zones.

## 5. VIVDS PROCESSOR UNIT

5.1. **Cabinet Mounting**. The VIVDS processor unit must be rack mountable.

5.2. **Environmental Requirements**. The VIVDS processor unit must be designed to operate reliably in the adverse environment found in the typical roadside traffic cabinet. It must meet the environmental

requirements set forth by the latest NEMA (National Electrical Manufacturers Association) TS1 and TS2 standards as well as the environmental requirements for Type 170, Type 179 and 2070 controllers. Operating temperature must be from -30°F to +165°F at 0% to 95% relative humidity, non-condensing.

5.3. **Electrical**. The VIVDS must have a modular electrical design.

The VIVDS must operate within a range of 89 to 135 VAC, 60 Hz single phase. Power to the VIVDS must be from the transient protected side of the AC power distribution system in the traffic control cabinet in which the VIVDS is installed.

Serial communications to the field setup computer must be through an RS 232, USB or Ethernet port. This port must be able to download the real time detection information needed to show detector actuations. A connector on the front of the VIVDS processor unit must be used for serial communications.

The unit must be equipped with RS 170 (monochrome) or RS170A (color) composite video inputs video inputs, so that signals from image sensors or other synchronous or asynchronous video sources can be processed in real time. BNC connectors on the front of the VIVDS processor unit or video patch panel must be used for all video inputs.

The unit must be equipped with a single RS 170 composite video output. This output must be capable of corresponding to any one of the video inputs, as selected remotely via the field setup computer or front panel switch. Multiple video outputs requiring external cable connections to create a combined single video output must not be acceptable. A BNC or RCA connector must be used for video output on the front of the processor unit. Any other video formats must be approved by a Department TRF Signal Operation Engineer before use.

Software upgrades or changes must be presented to and approved by the Department's TRF-TM Division before use. Failure to do so will be grounds for termination of contract and probation for responsible partys.

The unit software and the supervisor software must include diagnostic software to allow testing the VIVDS functions. This must include the capability to set and clear individual detector outputs and display the status of inputs to enable setup and troubleshooting in the field.

## 6. CAMERA ASSEMBLY

6.1. **Camera**. The video detection system must use medium resolution, monochrome image sensors as the video source for real time vehicle detection. The cameras must be approved for use with the VIVDS processor unit by the supplier of the VIVDS. As a minimum, each camera must provide the following capabilities:

- Images must be produced with a Charge Coupled Device (CCD) sensing element with horizontal resolution of at least 480 lines for black and white or 470 lines for color and vertical resolution of at least 350 lines for black and white or color. Images must be output as a video signal conforming to RS170.
- Useable video and resolvable features in the video image must be produced when those features have luminance levels as low as 0.1 lux for black and white, and as low as 1.0 lux for color, for night use.
- Useable video and resolvable features in the video image must be produced when those features have luminance levels as high as 10,000 lux during the day.
- The camera must include an electronic shutter or auto-iris control based upon average scene luminance and must be equipped with an electronic shutter or auto-iris lens with variable focal length and variable focus that can be adjusted without opening up the camera housing to suit the site geometry. The variable focal length must be adjustable from 6 mm to 34 mm.

6.2. **Camera and Lens Assembly**. The camera and lens assembly must be housed in an environmental enclosure that provides the following capabilities:

- The enclosure must be waterproof and dust tight to the latest NEMA 4 specifications.

- The enclosure must allow the camera to operate satisfactorily over an ambient temperature range from -30°F to +140°F while exposed to precipitation as well as direct sunlight.
- The enclosure must allow the camera horizon to be rotated in the field during installation.
- The enclosure must include a provision at the rear of the enclosure for connection of power and video signal cables fabricated at the factory. Input power to the environmental enclosure must be nominally 115 VAC 60 Hz.
- A thermostatically controlled heater must be at the front of the enclosure to prevent the formation of ice and condensation, as well as to assure proper operation of the lens's iris mechanism. The heater must not interfere with the operation of the camera electronics, and it must not cause interference with the video signal.
- The enclosure must be light colored or unfinished and must include a sun shield to minimize solar heating. The front edge of the sunshield must protrude beyond the front edge of the environmental enclosure and must include provision to divert water flow to the sides of the sunshield. The amount of overhang of the sun shield must be adjustable to block the view of the horizon to prevent direct sunlight from entering the lens. Any plastics used in the enclosure must include ultra violet inhibitors.
- The total weight of the image sensor in the environmental enclosure with sunshield must be less than 10 lb.
- When operating in the environmental enclosure with power and video signal cables connected, the image sensor must meet FCC class B requirements for electromagnetic interference emissions.

The video output of the cameras must be isolated from earth ground. All video connections for the cameras to the video interface panel must also be isolated from earth ground.

Use waterproof, quick disconnect connectors to the image sensor for both video and power.

Provide a camera interface panel capable of being mounted to sidewalls of a controller cabinet for protection of the VIVDS processor unit, camera video and power inputs/outputs. The panel must consist of, as a minimum, 4 Edco CX06 coax protectors, an Edco ACP-340 for the cameras and VIVDS processor unit power, a 10 amp breaker, a convenience outlet protected the ACP-340 and a terminal strip with a minimum of sixteen 8-32 binder head screws. The terminal strip must be protected by a piece of 1/8 in. Plexiglas.

When the connection between the image sensor and the VIVDS processor unit is coaxial cable, the coaxial cable used must be a low loss, 75 ohm, precision video cable suited for outdoor installation, such as Belden 8281 or a Department-approved equal.

Camera mounting hardware must allow for vertical or horizontal mounting to the camera enclosure. Pelco AS-0166-4-62 or equivalent is acceptable.

## 7. FIELD COMMUNICATION LINK

The field communications link must be a one way communications connection from the camera to the equipment cabinet. The primary communications link media may be coaxial cable or fiber optic cable accompanied by a 3 conductor minimum 18 AWG, 24 VDC or 115 VAC camera power cable, or appropriate cable as approved.

The following requirements must govern for the various types of field communications link media described on the plans:

7.1. **Coaxial Cable**. In locations where the plans indicate coaxial cable is required as the primary communications link, this cable must be of the RG 59 type with a nominal impedance of 75 ohms. All cable must have a polyethylene dielectric with copper braid shield having a minimum of 98% shield coverage and not greater than 0.78 dB attenuation per 100 feet at 10 MHz with a minimum 18 AWG external 3 conductor power cable or approved equivalent as directed.

7.2. **Fiber Optic Cable**. If shown on the plans, furnish fiber optic cable in accordance with the Special Specification for fiber optic cable.

7.3. **Twisted Wire Pairs**. Must be Belden 9556 or equivalent 18 AWG TWP control cable.

All connection cables must be continuous from the equipment cabinet to the camera. No splices of any type will be permitted.

Install lightning and transient surge suppression devices on the processor side of the field communications link to protect the peripheral devices. The suppression devices must be all solid state. Lightning protection is not required for fiber optic communication lines. The devices must present high impedance to, and must not interfere with, the communications lines during normal operation. The suppression devices must not allow the peak voltage on any line to exceed 300% of the normal operating peak voltage at any time. The response time of the devices must not exceed 5 nanoseconds.

## 8. VIVDS SET-UP SYSTEM

The minimum VIVDS set-up system, as needed for detector setup and viewing of vehicle detections, must consist of a field setup computer and Windows based interface software (if required) or a video monitor with interface software built-in to the VIVDS processor unit. Live video (30 frames per second) must be available on the field setup computer to determine proper operation of detectors. The field set-up computer as a minimum, must have an NTSC video input port or equivalent.

If a field setup computer is required for system set-up, it must be supplied by the supplier of the VIVDS.

The field setup computer must include all necessary cabling and a Windows based program to interface with the VIVDS processor unit. This software must provide an easy to use graphical user interface and support all models/versions of the supplied VIVDS.

Live video with the detection overlaid is required for field verification of the system.

## 9. TEMPORARY USE AND RETESTING

9.1. **Temporary Use**. When shown on the plans, the VIVDS equipment must be used to provide vehicle detection on a temporary basis. When the permanent vehicle detection system and related equipment are installed and made operational, the VIVDS equipment must be carefully removed and delivered to the location shown on the plans.

9.2. **State Retesting and Acceptance**. Before acceptance, all VIVDS equipment may be retested by the Department, even if the system was operating properly before removal. Repair or replace any equipment damaged during removal or transport and any equipment that does not meet the various test requirements.

## 10. OPERATION FROM CENTRAL CONTROL

The central control must transmit and receive all information needed for detector setup, monitor the vehicle detection, view the vehicle traffic flow at a rate of 2 frames per second or greater for telephone, or 5 frames per second or greater for ISDN lines (as specified by the plans), and interrogate all required stored data. The remote communications link between the VIVDS processor unit and central control may be dial-up (telephone or ISDN lines) or dedicated twisted wire pair communications cable which may be accompanied with coaxial cable or fiber-optic cable, as shown on the plans. Communications with the central control must not interfere with the on-street detection of the VIVDS processor. Quality of the video at 2 frames per second rate must be such that the view with the traffic flow is clear and in focus.

## 11. INSTALLATION AND TRAINING

The supplier of the video detection system must supervise the installation and testing of the video and computer equipment. A factory certified representative from the supplier must be on site during installation.

If the field setup computer is furnished by the Department, such installation and testing must be done at the time that training is conducted.

Provide up to 2 days of training to personnel of the Department in the operation, setup and maintenance of the video detection system. Provide instruction and materials for a maximum of 20 persons and conduct at a location selected by the Department. The Department will be responsible for any travel and room and board expenses for its own personnel.

Instruction personnel are required to be certified by the equipment manufacturer. The User's Guide is not an adequate substitute for practical, classroom training and formal certification by an approved agency.

Formal levels of factory authorized training are required for installers, contractors, and system operators. All training must be certified by the manufacturer.

## 12. WARRANTY, MAINTENANCE, AND SUPPORT

The video detection system must be warranted to be free of defects in material and workmanship for a period of 5 yr. from date of shipment from the supplier's facility. During the warranty period, the supplier must repair with new or refurbished materials, or replace at no charge, any product containing a warranty defect provided the product is returned FOB to the supplier's factory or authorized repair site. Return product repair or replaced under warranty by the supplier with transportation prepaid. This warranty does not apply to products damaged by accident, improperly operated, abused, serviced by unauthorized personnel or unauthorized modification.

During the warranty period, technical support must be available from the supplier via telephone within 4 hr. of the time a call is made by a user, and this support must be available from factory certified personnel or factory certified installers.

Ongoing software support by the supplier must include updates of the VIVDS processor unit and supervisor software (if a field setup computer is required for set up). Provide these updates free of charge during the warranty period. The update of the VIVDS software to be NTCIP compliant must be included.

The supplier must maintain a program for technical support and software updates following expiration of the warranty period. Make this program available to the Department in the form of a separate agreement for continuing support.

The supplier must maintain an ongoing program of technical support for the wireless camera system. This technical support must be available via telephone or personnel sent to the installation site.

The supplier must maintain an adequate inventory of parts to support maintenance and repair of the camera system.

## 13. MEASUREMENT

The VIVDS will be measured as each major system component furnished, installed, made fully operational, and tested in accordance with this Special Specification or as directed.

The VIVDS communication cable will be measured by the foot of the appropriate media type furnished, installed, made fully operational, and tested in accordance with this Specification, other referenced Special Specifications or as directed.

When the VIVDS is used on a temporary basis, the VIVDS will be measured as each system furnished, installed, made fully operational, including reconfiguration and removal if required by the plans, and tested in accordance with this Special Specification or as directed.

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.

When recorded video is required by the plans it will be paid for by each camera recorded.

## 14. PAYMENT

The work performed, materials, and all accompanying software furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "VIVDS Processor System,” "VIVDS Camera Assembly,” "VIVDS Central Control,” "VIVDS Set-up System,” "VIVDS Temporary,” "VIVDS Communication Cable (Coaxial)," "VIVDS Communication Cable (Fiber Optic),” and “VIVDS Video Recording,” These prices are full compensation for furnishing, placing, and testing all materials and equipment, and for all tools, labor, equipment, hardware, operational software packages, supplies, support, personnel training, shop drawings, documentation, and incidentals. A 3-conductor power cable must be included with the communication cable.

These prices also include any and all interfaces required for the field and remote communications links along with any associated peripheral equipment, including cables; all associated mounting hardware and associated field equipment; required for a complete and fully functional visual image vehicle detection system component.

**CITY OF SAN ANGELO**
**STANDARD SPECIFICATIONS**

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# CITY OF SAN ANGELO

# ITEM 200

# SUBGRADE PREPARATION

## 200.1 DESCRIPTION.

This Item shall govern the scarifying, blading, and rolling of the subgrade to obtain uniform texture and density throughout the required depth as shown on the Plans.

## 200.2 TESTING.

The subgrade under areas to be paved shall be compacted to a minimum depth of **8 inches** and to a density of **not less than 95 percent for cohesive soils** or **100 percent for noncohesive soils** of the maximum density as determined by Test Method Tex-114-E / ASTM D 698**.** Noncohesive soils, for the purpose of determining compaction control, are those with a plasticity index (PI) of less than 6. The material to be compacted shall be **within +/- 2 percent of optimum moisture content** before rolled to obtain the prescribed compaction (except for expansive soils).

Field density determination will be made in accordance with Test Method Tex-115-E / ASTM D 2922 for field density and ASTM D 3017 for moisture content using a nuclear gage. If nuclear gages are to be used for density determination, the machines shall be calibrated in accordance with ASTM D 2922 using blocks of materials with densities that extend through a range representative of the density of the proposed embankment material.

Compaction is to be tested for density and moisture content acceptance as per Detail S-EE-1.

AASHTO T99 or T-180 (Moisture-Density) is required for soils that have more than 30 percent retained on the 3/4-inch sieve. The moisture-density relationship test procedures ASTM D 698 and D1557 are not applicable for materials with greater than 30 percent retained on the 3/4-inch sieve. A replacement procedure (ASTM D 4718) for the coarse material (greater than 3/4-inch) is used with ASTM methods but only until up to 30 percent is retained. Maximum density testing (ASTM D 4253) may be used but it also limits the material retained on the 1-1/2-inch sieve to 30 percent. The AASHTO T-99 and T-180 are similar to ASTM D 698 and D 1557, except they do not limit the replacement of the coarse material.

Stones or rock fragments larger than 4 inches (100 mm) in their greatest dimension will not be permitted in the top 6 inches (150 mm) of the subgrade. The finished grading operations, conforming to the typical cross section, shall be completed and maintained at least 1,000 feet (300 m) ahead of the paving operations or as directed by the City.

## 200.3 CONSTRUCTION METHODS.

The roadbed or parking lot subgrade, as case may be, shall be excavated and shaped in conformity with the typical sections shown on the Plans and to the lines and grades established by the City. All unstable or otherwise objectionable material shall be removed or otherwise broken off to a depth of not less than six (6) inches below the surface of the subgrade. Holes or depressions resulting from the removal of such material shall be backfilled with suitable material compacted in layers not to exceed six (6) inches. All soft and unstable material and other portions of the subgrade, which will not compact readily or serve the intended purpose, shall be removed as directed. No direct payment will be made for such removal.

The subgrade shall be scarified to the depth shown on the Plans, then bladed and compacted in the manner outlined in the following paragraph, "Finishing and Compaction". The surface of the subgrade shall be finished to line and grade as established, and be in conformity with the typical sections shown on the Plans. Any deviation in excess of one-half (1/2) inch in cross section and in a length of sixteen feet measured longitudinally shall be corrected by loosening, adding or removing material, reshaping and compacting by sprinkling and rolling. Material excavated in the preparation of the subgrade shall be disposed in a manner acceptable to the City.

## 200.4 FINISHING AND COMPACTION.

The subgrade course, including an area one foot back of the proposed curb line, or as the case may be, shall be sprinkled as required and rolled as directed until a uniform compaction and the required density is obtained. Compaction of the subgrade may be done using any of the rolling equipment acceptable to the City. Rolling shall continue until the subgrade has been compacted to the required testing minimums per Section 200.2.

Tests will be made at the times and locations selected by the City. Notification will be a minimum of 24 hours.

Rolling shall progress gradually from the sides to the center of the lane under construction by lapping uniformly each preceding tract by at least 12 inches.

After rolling and watering, the subgrade shall be checked by the use of string line or instrument and all portions that do not conform to the lines and grades as shown on the Plans shall be scarified for at least six (6) inches, corrected and recompacted to correct elevations.

Until the base course or pavement is placed, the subgrade shall be maintained free from cuts and depressions, in a smooth and compacted condition true to lines and grade and to the density requirements contained herein. All of the Contractor's hauling and other equipment used in such a way as to cause rutting and raveling of the subgrade shall either be removed from the work or suitable run-ways or other equivalent means shall be provided to prevent rutting.

The Contractor shall be responsible for maintaining and protecting the roadbed or the parking lot subgrade, as the case may be, for the entire length of the project.

During construction, grading of the subgrade shall be conducted so that berms of earth or other material do not substantially impede the flow of storm waters. Ditches and drains along the subgrade shall be maintained so as to drain effectively.

## 200.5. MEASUREMENT.

The subgrade preparation will be measured by the number of square yards of subgrade prepared and accepted by the Owner.

## 200.6. PAYMENT.

The amount of subgrade area measured as outlined under "Measurement" will be paid for at a unit price bid for this Item which will be full compensation for removing excess material, shaping, fine grading and compacting the subgrade; for furnishing and hauling all materials, blading and finishing and all labor, tools and incidentals necessary to complete the work.

# CITY OF SAN ANGELO

# ITEM 264

# LIME AND LIME SLURRY

## 264.1. DESCRIPTION.

This Item establishes the requirements for hydrated lime, quicklime and commercial lime slurry

**CAUTION:** Use of quicklime can be dangerous. Users should become informed of the recommended precautions in the handling, storage and use of quicklime.

## 264.2. TYPES.

The various types and grades are defined and identified as follows:

**(1) Type A, Hydrated Lime,** a dry powdered material consisting essentially of calcium hydroxide.

**(2) Type B, Commercial Lime Slurry**, a liquid mixture of essentially hydrated lime solid and water in slurry form.

**(3) Type C, Quicklime,** a dry material consisting essentially of calcium oxide. It shall be furnished in either of two grades which differ is sizing.

**Grade DS,** "pebble" quicklime of a gradation suitable for use in the preparation of a slurry for "Wet Placing".

**Grade S,** finely graded quicklime for use in the preparation of slurry for wet placing. (Note: Due to the possibility of appreciable amounts of finely divided, powdered quicklime being present in this product, the use of Type C, Grade S Quicklime is restricted to "Slurry Placing" only. It is considered to be unsuitable for "Dry Placing".

## 264.3. GENERAL:

Lime shall be applied as provided for in the governing specifications, as a dry material or as a mixture of lime solids and water in the form of lime slurry.

For dry application, Type A Hydrated Lime or Type C, Quicklime of Grade DS only may be used where specifications permit.

For wet application, lime slurry may be delivered to the job site as Type B, Commercial Lime Slurry or a lime slurry may be prepared at the job site or other location approved by the City, by using Type A Hydrated Lime of Type C Quicklime as specified.

The lime and lime slurry being furnished under the terms of this specification shall, in addition to all other requirements, also meet the following chemical and physical requirements.

**Chemical and Physical Requirements for Lime and Lime Slurry**

| | Type | | |
|---|---|---|---|
| **Chemical:** | **A** | **B** | **C** |
| Total "active" lime content, % by wt (i.e., % by wt Ca(OH)2 + % by wt CaO, if present) | 90.0 min* | 87.0 min** | - |
| Unhydrated lime content, % by wt CaO: | 5.0 max | - | 87.0 min |
| "Free Water" content, % by wt H2O: | 5.0 max | - | - |
| **Physical:** | | | |
| *Wet sieve requirement, as % by wt residue:* | | | |
| Retained on No. 6 (3360 Micron) sieve: | 0.2 max | 0.2 max** | 8.0 max*** |
| Retained on No. 30 (590 micron) sieve: | 4.0 max | 4.0 max** | - |
| *Dry sieve requirement, as % by wt residue:* | | | |
| Retained on a 1-inch (25 mm) sieve: | - | - | - |
| Retained on a 3/4 inch (19.0) mm sieve: | - | - | 10.0 max |
| Retained on a No. 100 (150 micron) sieve: | - | - | Grade DS-80% min Grade S-No Limits |

Note * No more then 5.0% by weight CaO (unhydrated lime) will be allowed in determining the total "active" lime content.

Note ** In "solids content" of the slurry.

Note *** The amount of total "active" lime content, as CaO, in material retained on the No. 6 sieve must not exceed 2.0 percent by weight of the original Type C lime.

Type B, Commercial Lime Slurry or a slurry prepared at the job site from Type A Hydrated Lime or Type C Quicklime shall be furnished at or above the minimum "Dry Solid" content as approved by the City and must be of a consistency that can be handled and uniformly applied without difficulty. The slurry shall be free of liquids other than water and any materials of a nature injurious or objectionable for the purpose intended.

## 264.4 SAMPLING AND TESTING.

The sampling and testing of lime shall be determined by test Method Tex-600-J, "Lime Testing Procedure" / NA.

## 264.5 MEASUREMENT AND PAYMENT.

Lime will be measured and paid for in accordance with the governing specifications for the items of construction in which lime is used.

**KSA**
**STANDARD SPECIFICATIONS**

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SECTION 02205

SOIL MATERIALS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Subsoil materials.

B. Topsoil materials.

1.2 RELATED SECTIONS

A. Geotechnical Report: Bore hole locations and finding of subsurface materials.

B. Section 01400 – Quality Control: Testing soil fill materials.

C. Section 02207 – Aggregate Materials.

D. Section 02225 – Excavating, Backfilling, and Compacting for Utilities.

1.3 REFERENCES

A. ASTM D698 – Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures.

B. ASTM D2487 – Classification of Soils for Engineering Purposes.

C. ASTM D2922 – Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).

D. ASTM D3017 – Test Method for Moisture Content of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).

1.4 SUBMITTALS FOR REVIEW

A. Section 01300 – Submittals: Procedures for submittals.

B. Samples: Submit, in air–tight containers, 10 lb. sample of each type of fill to testing laboratory. All off-site materials must be approved by the Engineer prior to installation.

1.5 SUBMITTALS FOR INFORMATION

A. Section 01300 – Submittals: Procedures for submittals.

B. Materials Source: Submit name of imported materials source.

1.6 QUALITY ASSURANCE

A. Perform Work in accordance with plans and specifications, TxDOT standards, and Owner requirements.

PART 2 PRODUCTS

2.1 SOIL MATERIALS

A. Soil Type S1 – Subgrade material:

1. Material remaining in place after excavation.

2. Suitable for slab/foundation subgrade, undisturbed nor over excavated.

3. Where subgrade soils are soft, loose, or otherwise unsatisfactory, the soil shall be removed and replaced with select fill or soil cement as determined by the Engineer.

B. Soil Type S2 – Common Fill:

1. Excavated and re-used material or from borrow approved by the Engineer.

2. Graded free of lumps larger than 3 inches, rocks larger than 2 inches, excessive silts and debris.

3. Do not use soil containing brush, roots, or similar organic matter.

4. Conforming to ASTM D2487 Class II or Class III soils with a liquid limit less than 40, and a plasticity index less than 20, but greater than 4.

C. Soil Type S3 – Select Fill:

1. Imported borrow material from borrow area approved by the Engineer. Material shall be tested for compliance by the Contractor and test results submitted to the Engineer for approval.

2. Clayey sand soils free from organic matter with no lumps larger than 1 inch, no rocks larger than ½ inch, nor excessive silts.

3. Do not use soils containing brush, roots, sod or other organic materials.

4. Select fill shall conform to ASTM D2487 Class II or Class III and shall have a liquid limit less than 30 with a plasticity index less than 15 but greater than 4.

D. Soil Type S4 – Top Soil:

1. Soil suitable for growth of surface cover. Material stripped and stockpiled from site or borrowed from off site.

2. Free from roots, brush, rocks, and other extraneous matter exceeding 1 inch in any direction. Free from weeds

3. Minimum 60% sand, Maximum 30% silts, Maximum 10% clay, no less than 6% and no more than 20% organic matter.

4. Submit test data showing compliance with this specification. Include percent weight of constituent material, material particle size, and pH.

2.2 SOURCE QUALITY CONTROL

A. Section 01400 – Quality Control: Testing and analysis of soil material.

B. Testing and Analysis of Subsoil Material: Perform in accordance with ASTM D698.

C. Testing and Analysis of Topsoil Material: Perform in accordance with ASTM D698.

D. If tests indicate materials do not meet specified requirements, change material and retest.

E. Provide materials of each type from same source throughout the Work. A change in source requires sampling, testing, and approval by the Engineer.

PART 3 EXECUTION

3.1 SOIL REMOVAL

A. Excavate soils from areas designated.

B. Remove lumped soil, boulders, and rock.

C. Stockpile excavated material in area designated on site and remove excess material not being used, from site.

3.2 STOCKPILING

A. Stockpile materials on site at locations designated by Engineer.

B. Stockpile in sufficient quantities to meet Project schedule and requirements.

C. Separate differing materials with dividers or stockpile apart to prevent mixing.

D. Prevent intermixing of soil types or contamination.

E. Direct surface water away from stockpile site to prevent erosion or deterioration of materials.

3.3 STOCKPILE CLEANUP

A. Excess material in stockpile shall be removed and disposed of at the end of the project.

B. Remove stockpile, leave area in a clean and neat condition. Grade site surface to prevent free standing surface water.

C. If a borrow area is indicated, leave area in a clean and neat condition. Grade site surface to prevent free standing surface water.

END OF SECTION

SECTION 02207

AGGREGATE MATERIALS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Aggregate materials.

1.2 RELATED SECTIONS

A. Section 01400 - Quality Control

B. Section 02205 - Soil Materials.

C. Section 02224 - Excavation, Backfilling, and Compacting for Structures.

D. Section 02225 - Excavation, Backfilling, and Compacting for Utilities.

1.3 REFERENCES

A. ASTM C29 - Unit Weight of Aggregate

B. ASTM C88 - Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate

C. ASTM C117 - Materials Finer than 75um (No. 200) Sieve in Mineral Aggregates by Washing

D. ASTM C131 - Resistance to Abrasion of Small Size Coarse Aggregate by Use of the Los Angeles Machine

E. ASTM C136 - Method for Sieve Analysis of Fine and Coarse Aggregates.

F. ASTM D75 - Sampling Aggregate

G. ASTM D693 - Crushed Stone, Crushed Slag, and Crushed Gravel for Dry-or Water-Bound Macadam Base Courses and Bituminous Macadam Base and Surface Courses of Pavements

H. ASTM D698 - Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures.

I. ASTM D2419 - Sand Equivalent Value of Soils and Fine Aggregate

J. ASTM D2487 - Classification of Soils for Engineering Purposes.

K. ASTM D2922 - Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).

L. ASTM D3017 - Test Method for Moisture Content of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).

M. ASTM D3665 - Random Sampling of Paving Materials

N. ASTM D4318 - Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

O. Texas Department of Transportation Standard Specifications for Construction of Highways, Streets and Bridges, 2004 Edition.

1.4 SUBMITTALS FOR REVIEW

A. Section 01300 - Submittals: Procedures for submittals.

B. Samples: Submit, in air-tight containers, 10 lb. sample of each type of material to testing laboratory.

1.5 SUBMITTALS FOR INFORMATION

A. Section 01300 - Submittals: Procedures for submittals.

B. Materials Source: Submit name of imported materials suppliers.

1.6 QUALITY ASSURANCE

A. Perform Work in accordance with plans and specification requirements and TxDOT standards.

PART 2 PRODUCTS

2.1 COARSE AGGREGATE MATERIALS

A. Coarse Aggregate Type A1 - Drain Rock:

1. As shown on the Plans, under structures and behind walls shall be clean, washed, sound durable, well-graded crushed rock, crushed gravel or natural stone gravel.

2. Conforming to ASTM C-33 Size No. 57 coarse aggregate between 1 inch and 2 inch.

B. Coarse Aggregate Type A2 - Pipe Embedment:

1. Angular 3/4 inch to 1 inch crushed rock or natural stone meeting the requirements of ASTM C-33 No. 57.

2. Embedment material shall be clean, washed, sound, durable and well graded.

C. Coarse Aggregate Type A3 - Foundation Material:

1. Coarse stone or crushed gravel.

2. Foundation material shall be pit run angular crushed, natural washed stone free of shale, clay, friable material and debris; well graded between 1 and 3 inches in size, with a minimum of 90% retained on a 1-inch sieve.

D. Coarse Aggregate Type A3-1 - Foundation Material for Unsuitable Subgrade:

1. Foundation material shall conform to the specification for TxDOT Item 247, Type "A", Grade 2.

E. Aggregate Type A4 - Pea Gravel:

1. Natural stone; washed, free of clay, shale, organic matter; graded in accordance with ASTM C136 to the following limits:

a. Minimum Size: 1/4 inch

b. Maximum Size: 5/8 inch

F. Aggregate Type A5 – Type "R" Modified Rock Riprap:

1. Natural stone, washed free of clay and shale, and shall meet all of the requirements of TxDOT Item 432, for Type R Stone Riprap with the following modifications:

a. Stones shall weight between 50 to 150 pounds with no less than 50 percent of the stones shall weigh more than 100 pounds.

b. Rock's longest dimension shall not exceed 3 times that of the shortest dimension.

c. Delete paragraphs 432.5 Measurement and 432.6 Payment, and refer to Section 01200 – Unit Bid Prices of these specifications.

## 2.2 FINE AGGREGATE MATERIALS

A. Fine Aggregate Type A5 - Sand:

1. Natural river or bank sand; washed, free of silt, clay, loam, friable or soluble materials and organic matter; graded in accordance with ASTM C136; within the following limits:

| Sieve Size | Percent Passing |
|---|---|
| No. 4 | 100 |
| No. 14 | 10 to 100 |
| No. 50 | 5 to 90 |
| No. 100 | 4 to 30 |
| No. 200 | 0 to 10 |

2.3 SOURCE QUALITY CONTROL

A. Section 01400 - Quality Control: Source testing and analysis of aggregate material.

B. Coarse Aggregate Material - Testing and Analysis: Perform in accordance with ASTM D698, and ASTM C33.

C. Fine Aggregate Material - Testing and Analysis: Perform in accordance with ASTM D698, and ASTM C33.

D. If tests indicate materials do not meet specified requirements, change material or material source and retest.

E. Provide materials of each type from same source throughout the Work. A change in source requires sampling, testing, and approval by the Engineer.

PART 3 EXECUTION

3.1 STOCKPILING

A. Stockpile materials on site at locations designated by the Engineer.

B. Stockpile in sufficient quantities to meet Project schedule and requirements.

C. Separate differing materials with dividers or stockpile apart to prevent mixing.

D. Direct surface water away from stockpile site so as to prevent erosion or deterioration of materials.

3.2 STOCKPILE CLEANUP

A. Remove stockpile; leave area in a clean and neat condition. Grade site surface to prevent freestanding surface water.

B. Leave unused materials in a neat, compact stockpile.

C. If a borrow area is indicated, leave area in a clean and neat condition.

D. Grade site surface to prevent freestanding surface water.

END OF SECTION

SECTION 02225

EXCAVATION, BACKFILLING, AND COMPACTING FOR UTILITIES

PART 1 GENERAL

1.1 SECTION INCLUDES:

A. Excavating, trenching, backfilling and compacting for water distribution mains, force mains, gravity sanitary sewers, manholes and other utility systems and appurtenances, and the disposal of excess excavated material.

1.2 RELATED SECTIONS:

A. Section 02205 – Soil Materials

B. Section 02207 – Aggregate Materials

C. Section 02220 – Trench and Excavation Safety System

1.3 REFERENCES:

A. ASTM C33 - Coarse Aggregates.

B. ASTM D698 - Standard Methods of Test for Moisture-Density Relations of Soil (Standard).

C. ASTM D1557 - Test for Moisture-Density Relations of Soil (Modified).

D. ASTM D2487 - Classification of Soils for Engineering Purposes.

E. ASTM D2922 - Density of Soil and Soil Aggregate In-Place by Nuclear Methods.

F. ASTM D3017 - Moisture Content of Soil and Soil Aggregate In-Place by Nuclear Methods.

G. ASTM D4254 - Minimum Index Density and Unit Weight of Soils and Calculations of Relative Density.

H. ASTM D4318 - Test for Liquid Limit, Plastic Limit and Plasticity Index of Soils.

I. OSHA - Occupational Safety and Health Administration and Related Regulations.

1.4 SUBMITTALS:

A. Procedures for Submittals: Section 01300.

B. Samples: Aggregate samples of material as required by the testing laboratory.

C. Quality Control Submittals: For information only.

1.5 PROTECTION OR REMOVAL OF UTILITY LINES:

A. The Contractor shall anticipate all underground obstructions such as, but not limited to, water mains, gas lines, storm and sanitary sewers, telephone or electric light or power ducts, concrete, and debris.

1. Any such lines or obstructions indicated on the Drawings show only the approximate locations and shall be verified in the field by the Contractor.

2. The Owner and Engineer will endeavor to familiarize the Contractor with all known utilities and obstructions, but this shall not relieve the Contractor from full responsibility in anticipating all underground obstructions whether or not shown on the Drawings.

B. The Contractor shall, at his own expense, maintain in proper working order and without interruption of service all existing utilities and services which may be encountered in the work.

1. With the consent of the Engineer and utility owner such service connections may be temporarily interrupted to permit the Contractor to remove designated lines or to make temporary changes in the locations of services.

2. The cost of making any temporary changes shall be at the Contractor's expense.

C. Notify all utility companies involved to have their utilities located and marked in the field.

1. All underground utilities shall then be uncovered to verify location and elevation before construction begins.

2. The Contractor shall obtain all necessary permits.

D. The Contractor shall obtain necessary permits, except right-of-way permits, required for completion of the project.

E. Utility Spacing: The spacing for utility lines shall meet the installation requirements and the requirements of the TCEQ.

1.6 PROJECT CONDITIONS:

A. Protection:

1. Erect sheeting, shoring and bracing as necessary for protection of persons, improvements, existing structures, and excavations.

2. Provide dewatering and drainage necessary to keep excavations free of water.

a. Dewatering System shall maintain the water level a minimum of 3 feet below the excavation.

b. Contractor shall provide and maintain all dewatering equipment during excavation, construction, backfill, and until utility is placed in service.

c. Contractor shall operate dewatering system continuously without interruption during weekends and/or holidays.

PART 2 PRODUCTS

2.1 MATERIALS:

A. General Site Fill: Section 02205.2.1.B – Soil Type S2 – Common Fill

B. Earth Backfill: Section 02205.2.1.C – Soil Type S3 – Select Fill

C. Topsoil: Section 02205.2.1.D – Soil Type S4 – Top Soil

D. Aggregate: Section 02207.2.1.B – Coarse Aggregate Type A2 – Pipe Embedment

E. Crushed Rock: Section 02207.2.1.D – Coarse Aggregate Type A3-1 – Foundation Material for Unsuitable Subgrade

F. Sand: Section 02207.2.2.A – Fine Aggregate Type A5 - Sand

PART 3 EXECUTION

3.1 EXAMINATION AND PREPARATION:

A. Examine utility routes and coordinate excavation work to eliminate installation conflicts.

B. Allow room for stockpiling excavated material and utility construction material during utility construction.

3.2 TRENCH EXCAVATION:

A. Procedure: Excavated to indicated or specified depths.

1. Excavate by open cut method.

2. Dispose of unacceptable backfill material and provide suitable material for backfill without additional expense.

3. During excavation, stockpile material suitable for backfilling in an orderly manner far enough from the bank of the trench to avoid overloading, slides, or cave-ins.

4. Grade as necessary to prevent surface water from flowing into trenches or other excavations.

5. Cut banks of trench as nearly vertical as practical.

a. Remove stones as necessary to avoid point-bearing.

b. Over-excavate wet or unstable soil from the trench bottom to permit construction of a more stable bed for pipe.

c. Over excavation shall be filled and tamped with clean dry sand or other approved material to the required grade.

6. Excavate the trench the proper width as shown.

a. If the trench width below the top of pipe is wider than specified in this Section or shown, install additional backfill.

b. No additional payment will be made for additional material or work required for installation.

7. Accurately grade the trench bottom to provide proper bedding as required for pipe installation.

8. If any excavation is carried beyond the lines and grades required or authorized, the Contractor shall, at his own expense, fill such space with concrete or other suitable material as directed by the Engineer. No additional payment will be made.

B. Sheeting and Bracing: Install sheeting and bracing necessary to support the sides of trenches and other excavations with vertical sides, as required by current OSHA regulations.

C. Water In Excavation:

1. Keep work free from ground or surface water at all times.

2. Provide pumps of adequate capacity or other approved method to remove water from the excavation in such a manner that it will not interfere with the progress of the work or the proper placing of other work.

D. Trenching Progress: Trenching operations shall not be in excess of 100 feet ahead of pipe laying operations in city streets or 2,000 feet in open country.

E. Existing Lawns and Shrubbery:

1. The Contractor shall take particular care to preserve existing lawns and shrubbery.

2. Make minor pipe alignment changes as may be necessary with approval from the Engineer.

F. Existing Pavement:

1. Existing pavement over trenches shall be removed to a width of 6 inches outside of the trench on each side.

2. Remove to a neat line by sawing method. No additional payment shall be made for saw-cutting.

3.3 Pipe Bedding:

A. Pipe Zone: The pipe zone is defined as including the pipe bedding, backfill to one-half the pipe diameter (the springline) and the initial backfill to 12 inches above the top of the pipe.

B. Class A Bedding:

1. Where shown on plans, the Contractor shall install the pipe in concrete encasement.

2. Concrete for encasement shall be Class A (3000-psi) compressive strength as specified in Section 03300.

3. Concrete for encasement, shall be included in the unit price bid per linear foot in place.

4. Sheeting and shoring will not be allowed in the pipe zone during or after installation of the pipe or embedment material, unless special provisions are made to ensure the specified compaction of bedding and pipe alignment is maintained after removal of sheeting and shoring.

5. Accurately grade the bottom of the trench 4 inches below the bottom of the pipe and limits of clear space on either side of the pipe.

6. Precautions shall be used to prevent pipe movement or deflection during construction.

7. Install pipe.

8. Place the concrete encasement to a minimum of 4 inches above the top of the pipe.

9. After the pipe and embedment have been placed, complete the backfilling of the pipe trenches to the proposed finished grade elevation by the following method:

a. Selected material, meeting the requirements for Type S2 Backfill, shall be first taken from the spoil ban and placed on both sides of the pip simultaneously in layers of not more that six (6) inches in loose thickness, and the layer shall be firmly compacted by had or mechanical tamping to the limits specified below.

b. The layers of backfill shall be sprinkled lightly with water if additional moisture is required for proper compaction.

c. This process of filling and tamping in layers shall be continued until the backfill is brought up to 18 inches above the top of the pipe.

d. Rolling compaction devices may be used to complete that backfill as required once the pipe has a minimum of 18 inches of compacted backfill place over the top of the pipe.

10. Compact the bedding and backfill to a minimum of 95 percent of maximum dry density per ASTM D698, maintaining moisture within ±2 percent of optimum or 70 percent of relative density per ASTM D4254.

C. Class B Bedding:

1. Where shown on plans, the Contractor shall install the pipe in concrete encasement.

2. Sheeting and shoring will not be allowed in the pipe zone during or after installation of the pipe or embedment material, unless special provisions are made to ensure the specified compaction of bedding and pipe alignment is maintained after removal of sheeting and shoring.

3. Accurately grade the bottom of the trench four (4) inches below the bottom of the pipe and limits of clear space on either side of the pipe.

4. Place a minimum of four (4) inches of compacted sand backfill up to the flow line of the pipe or above before pipe is laid.

5. The initial layer of embedment material placed to receive the pipe shall be brought up to a grade slightly higher than that required for the bottom of the pipe and the pipe shall be placed.

6. Adjustment to the grade line shall be made by tamping, scraping away, the removal of the slight excess amount of embedment material, or filling with embedment materials. Wedging or blocking up of pipe will not be permitted.

7. Each pipe section shall have a uniform bearing on the embedment for the full length of the pipe, except immediately at the joint.

8. After each pipe has been graded, aligned, placed in final position on the bedding material and joint made, sufficient embedment material shall be deposited and compacted under and around each side of the pipe and back of the bell or end thereof to hold the pipe in proper position and alignment during subsequent pipe jointing and embedment operations.

9. Additional Sand Embedment Material (Type A5) shall be deposited simultaneously on each side of pipe and compacted uniformly to the a depth of six (6) inches above the top of the pipe.

10. After the pipe and embedment have been placed, complete the backfilling of the pipe trenches to the proposed finished grade elevation by the following method:

a. Selected material, meeting the requirements for Type S2 Backfill, shall be first taken from the spoil ban and placed on both sides of

the pip simultaneously in layers of not more that six (6) inches in loose thickness, and the layer shall be firmly compacted by had or mechanical tamping to the limits specified below.

b. The layers of backfill shall be sprinkled lightly with water if additional moisture is required for proper compaction.

c. This process of filling and tamping in layers shall be continued until the backfill is brought up to 18 inches above the top of the pipe.

d. Rolling compaction devices may be used to complete that backfill as required once the pipe has a minimum of 18 inches of compacted backfill place over the top of the pipe.

11. Compact the bedding and backfill to a minimum of 95 percent of maximum dry density per ASTM D698, maintaining moisture within ±2 percent of optimum or 70 percent of relative density per ASTM D4254.

D. Class C Bedding:

1. All force main pipe bedding shall be Class C unless otherwise stated.

2. Sheeting and shoring will not be allowed in the pipe zone during or after installation of the pipe or embedment material, unless special provisions are made to ensure the specified compaction of bedding and pipe alignment is maintained after removal of sheeting and shoring.

3. Accurately grade the bottom of the trench four (4) inches below the bottom of the pipe and to the limits of the clear space on either side of the pipe.

4. Place a minimum of four (4) inches of compacted Course Aggregate Material (Type A2) below the pipe and to the spring line of the pipe.

5. The initial layer of embedment material placed to receive the pipe shall be brought up to a grade slightly higher than that required for the bottom of the pipe and the pipe shall be placed.

6. Adjustment to the grade line shall be made by tamping, scraping away, the removal of the slight excess amount of embedment material, or filling with embedment materials. Wedging or blocking up of pipe will not be permitted.

7. Each pipe section shall have a uniform bearing on the embedment for the full length of the pipe, except immediately at the joint.

8. After each pipe has been graded, aligned, placed in final position on the bedding material and joint made, sufficient embedment material shall be deposited and compacted under and around each side of the pipe and back of the bell or end thereof to hold the pipe in proper position and alignment during subsequent pipe jointing and embedment operations.

9. Additional Course Aggregate Material (Type A2) shall be deposited simultaneously on each side of pipe and compacted uniformly to the spring line.

10. Place Select Backfill Material (Type S3) shall be deposited simultaneously on each side of pipe and compacted uniformly to the top of the pipe.

11. After the pipe and embedment have been placed, complete the backfilling of the pipe trenches to the proposed finished grade elevation by the following method:

    a. Selected material, meeting the requirements for Type S2 Backfill, shall be first taken from the spoil ban and placed on both sides of the pip simultaneously in layers of not more that six (6) inches in loose thickness, and the layer shall be firmly compacted by had or mechanical tamping to the limits specified below.

    b. The layers of backfill shall be sprinkled lightly with water if additional moisture is required for proper compaction.

    c. This process of filling and tamping in layers shall be continued until the backfill is brought up to 18 inches above the top of the pipe.

    d. Rolling compaction devices may be used to complete that backfill as required once the pipe has a minimum of 18 inches of compacted backfill place over the top of the pipe.

12. Compact the bedding and backfill to a minimum of 95 percent of maximum dry density per ASTM D698, maintaining moisture within ±2 percent of optimum or 70 percent of relative density per ASTM D4254.

E. Class D Bedding:

1. Class D Bedding shall be used only when directed by the Engineer or the Engineer's Representative for the proposed waterline installation.

2. Sheeting and shoring will not be allowed in the pipe zone during or after installation of the pipe or embedment material, unless special provisions are made to ensure the specified compaction of bedding and pipe alignment is maintained after removal of sheeting and shoring.

3. Place and compact Foundation Material (Type A3) as required to obtain a stable foundation to a depth of four (4) inched below the bottom of the pipe and to the limits of the clear space on either side of the pipe

4. Place filter fabric, Dupont Typar filter fabric, or engineer approved equal, to the limits of the placement of the foundation material, were required the filter fabric shall be overlapped a minimum of 12 inches.

5. Place a minimum of four (4) inches of compacted Course Aggregate Material (Type A2) below the pipe and to the spring line of the pipe.

6. The initial layer of embedment material placed to receive the pipe shall be brought up to a grade slightly higher than that required for the bottom of the pipe and the pipe shall be placed.

7. Adjustment to the grade line shall be made by tamping, scraping away, the removal of the slight excess amount of embedment material, or filling with embedment materials. Wedging or blocking up of pipe will not be permitted.

8. Each pipe section shall have a uniform bearing on the embedment for the full length of the pipe, except immediately at the joint.

9. After each pipe has been graded, aligned, placed in final position on the bedding material and joint made, sufficient embedment material shall be deposited and compacted under and around each side of the pipe and back of the bell or end thereof to hold the pipe in proper position and alignment during subsequent pipe jointing and embedment operations.

10. Additional Course Aggregate (Type A2) material shall be deposited simultaneously on each side of pipe and compacted uniformly to the spring line.

11. Place Select Backfill Material (Type S3) shall be deposited simultaneously on each side of pipe and compacted uniformly to the top of the pipe.

12. After the pipe and embedment have been placed, complete the backfilling of the pipe trenches to the proposed finished grade elevation by the following method:

    a. Selected material, meeting the requirements for Type S2 Backfill, shall be first taken from the spoil ban and placed on both sides of the pip simultaneously in layers of not more that six (6) inches in loose thickness, and the layer shall be firmly compacted by had or mechanical tamping to the limits specified below.

    b. The layers of backfill shall be sprinkled lightly with water if additional moisture is required for proper compaction.

    c. This process of filling and tamping in layers shall be continued until the backfill is brought up to 18 inches above the top of the pipe.

    d. Rolling compaction devices may be used to complete that backfill as required once the pipe has a minimum of 18 inches of compacted backfill place over the top of the pipe.

13. Compact the bedding and backfill to a minimum of 95 percent of maximum dry density per ASTM D698, maintaining moisture within ±2 percent of optimum or 70 percent of relative density per ASTM D4254.

F. Class E Bedding:

1. All gravity sewer pipe bedding shall be Class E unless otherwise stated.

2. Sheeting and shoring will not be allowed in the pipe zone during or after installation of the pipe or embedment material, unless special provisions are made to ensure the specified compaction of bedding and pipe alignment is maintained after removal of sheeting and shoring.

3. Accurately grade the bottom of the trench four (4) inches below the bottom of the pipe and to the limits of the clear space on either side of the pipe.

4. Place a minimum of four (4) inches of compacted Course Aggregate Material (Type A2) below the pipe and to the spring line of the pipe.

5. The initial layer of embedment material placed to receive the pipe shall be brought up to a grade slightly higher than that required for the bottom of the pipe and the pipe shall be placed.

6. Adjustment to the grade line shall be made by tamping, scraping away, the removal of the slight excess amount of embedment material, or filling with embedment materials. Wedging or blocking up of pipe will not be permitted.

7. Each pipe section shall have a uniform bearing on the embedment for the full length of the pipe, except immediately at the joint.

8. After each pipe has been graded, aligned, placed in final position on the bedding material and joint made, sufficient embedment material shall be deposited and compacted under and around each side of the pipe and back of the bell or end thereof to hold the pipe in proper position and alignment during subsequent pipe jointing and embedment operations.

9. Additional Course Aggregate Material (Type A2) shall be deposited simultaneously on each side of pipe and compacted uniformly to the spring line.

10. Place Select Backfill Material (Type S3) shall be deposited simultaneously on each side of pipe and compacted uniformly to a minimum of 12 inches above the top of the pipe.

11. After the pipe and embedment have been placed, complete the backfilling of the pipe trenches to the proposed finished grade elevation by the following method:

    a. Selected material, meeting the requirements for Type S2 Backfill, shall be first taken from the spoil ban and placed on both sides of

the pip simultaneously in layers of not more that six (6) inches in loose thickness, and the layer shall be firmly compacted by had or mechanical tamping to the limits specified below.

b. The layers of backfill shall be sprinkled lightly with water if additional moisture is required for proper compaction.

c. This process of filling and tamping in layers shall be continued until the backfill is brought up to 18 inches above the top of the pipe.

d. Rolling compaction devices may be used to complete that backfill as required once the pipe has a minimum of 18 inches of compacted backfill place over the top of the pipe.

12. Compact the bedding and backfill to a minimum of 95 percent of maximum dry density per ASTM D698, maintaining moisture within ±2 percent of optimum or 70 percent of relative density per ASTM D4254.

G. Class F Bedding:

1. Class F Bedding shall be used only when directed by the Engineer or the Engineer's Representative for the proposed sanitary sewer installation.

2. Sheeting and shoring will not be allowed in the pipe zone during or after installation of the pipe or embedment material, unless special provisions are made to ensure the specified compaction of bedding and pipe alignment is maintained after removal of sheeting and shoring.

3. Place and compact Foundation Material (Type A3) as required to obtain a stable foundation to a depth of four (4) inched below the bottom of the pipe and to the limits of the clear space on either side of the pipe

4. Place filter fabric, Dupont Typar filter fabric, or engineer approved equal, to the limits of the placement of the foundation material, were required the filter fabric shall be overlapped a minimum of 12 inches.

5. Place a minimum of four (4) inches of compacted Course Aggregate Material (Type A2) below the pipe and to the spring line of the pipe.

6. The initial layer of embedment material placed to receive the pipe shall be brought up to a grade slightly higher than that required for the bottom of the pipe and the pipe shall be placed.

7. Adjustment to the grade line shall be made by tamping, scraping away, the removal of the slight excess amount of embedment material, or filling with embedment materials. Wedging or blocking up of pipe will not be permitted.

8. Each pipe section shall have a uniform bearing on the embedment for the full length of the pipe, except immediately at the joint.

9. After each pipe has been graded, aligned, placed in final position on the bedding material and joint made, sufficient embedment material shall be deposited and compacted under and around each side of the pipe and back of the bell or end thereof to hold the pipe in proper position and alignment during subsequent pipe jointing and embedment operations.

10. Additional Course Aggregate (Type A2) material shall be deposited simultaneously on each side of pipe and compacted uniformly to the spring line.

11. Place Select Backfill Material (Type S3) shall be deposited simultaneously on each side of pipe and compacted uniformly to a minimum of 12 inches above the top of the pipe.

12. After the pipe and embedment have been placed, complete the backfilling of the pipe trenches to the proposed finished grade elevation by the following method:

    a. Selected material, meeting the requirements for Type S2 Backfill, shall be first taken from the spoil ban and placed on both sides of the pip simultaneously in layers of not more that six (6) inches in loose thickness, and the layer shall be firmly compacted by had or mechanical tamping to the limits specified below.

    b. The layers of backfill shall be sprinkled lightly with water if additional moisture is required for proper compaction.

    c. This process of filling and tamping in layers shall be continued until the backfill is brought up to 18 inches above the top of the pipe.

    d. Rolling compaction devices may be used to complete that backfill as required once the pipe has a minimum of 18 inches of compacted backfill place over the top of the pipe.

13. Compact the bedding and backfill to a minimum of 95 percent of maximum dry density per ASTM D698, maintaining moisture within ±2 percent of optimum or 70 percent of relative density per ASTM D4254.

3.4 UTILITY INSTALLATION:

A. Sanitary Sewers (See 02731 Small Diameter Sanitary Sewer Systems and 02730 Pressurized Sanitary Sewer System for further detail):

1. Limit clear space on either side of the pipe to 12 inches.

2. Above the pipe, cut as wide as necessary to sheet and brace and properly perform the work.

3. Provide class of bedding as shown.

4. Avoid interference of water lines with other utilities.

5. Install piping and appurtenances as specified.

B. Water Supply and Distribution Lsines:

1. Provide a minimum cover over the top of the pipe as indicated.

2. Avoid interference of water lines with other utilities.

3. Provide class of bedding as shown.

4. Install piping and appurtenances as specified.

C. Electrical System:

1. Trench banks for conduit lines need not be kept vertical but may be sloped or widened to such general limits as may be set, provided there is no interference with other utilities.

2. Over-excavating and backfilling with suitable selected material where rock is encountered will not be required except for a gradual cushioning toward points of abrupt drop-off in the rock to levels considerably below the grade of the conduit.

3. Special trenching requirements for conduits, direct-buried electrical cables and duct lines are specified in Division 16 - Electrical.

D. Excavation for Appurtenances:

1. Excavate sufficiently for manholes, utility pull boxes, storm sewer junction boxes, curb inlets, and similar structures to leave at least 2 feet clear between the outer surfaces and the embankment or timber that may be used to hold and protect the banks.

2. Any over-depth excavation below such appurtenances not directed will be considered unauthorized and will be refilled with concrete, as directed by the Engineer, at no additional cost to the Owner.

3.5 BACKFILLING:

A. Criteria:

1. Backfill trenches to ground surface with material as specified.

2. Reopen trenches improperly backfilled to depth required for proper compaction.

3. Refill and compact as specified, or otherwise correct the condition in an approved manner.

B. Open Areas:

1. Above the pipe zone, deposit earth backfill in 8-inch lifts.

2. Mound excess material over trench as shown.

3. Excavated material placed shall be free of rock greater than 6 inches in any direction.

4. All forms, lumber, trash and debris shall be removed from trenches, manholes and other utility structures.

5. Backfill for manholes, utility pull boxes and other utility structures shall be placed in accordance with applicable Specification Sections.

C. Pavement Section:

1. Above pipe zone, place compacted ASTM D2487 Class II material in 6-inch lifts.

2. Compact to 95% of maximum density within 2% of optimum moisture per ASTM D698.

3. Complete the backfill with aggregate base course and asphalt paving as specified and detailed.

3.6 DISPOSAL OF EXCESS MATERIAL:

A. Excavated materials unsuitable for the backfilling, or in excess of that required for backfilling shall be disposed of by the Contractor at eligible locations as or approved by the Engineer.

B. Desirable topsoil, sod, etc. shall be carefully piled separately in its original position when required.

C. Excavated materials shall be handled at all times in such a manner as to cause a minimum inconvenience to public travel and to permit safe and convenient access to private and public property adjacent to or along the line of the work.

D. In parkways and easements where it is necessary to deposit excavated materials on lawns during the work, burlap or similar materials shall be placed on the lawn to prevent contact between excavated materials and the lawn.

E. Suitable excavated materials shall be piled adjacent to the work to be used for backfilling.

F. Remove waste and excess excavated material from the construction site before final inspection.

G. Legally dispose of material at a licensed site or with written and notarized permission from the property owner for a private disposal site.

H. All cost associated with waste material removal and disposal shall be paid for by the Contractor.

END OF SECTION

SECTION 02240

CARE OF WATER DURING CONSTRUCTION

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Furnish labor, materials, equipment and incidentals, including pumps, piping and other facilities necessary to remove surface and groundwater as needed to perform the required project construction.

B. Build and maintain the necessary temporary impounding works, channels, and diversions. Remove the temporary works, equipment, and materials after they have served their purpose in strict accordance with this section of the specifications and the applicable drawings.

1.2 SUBMITTALS

A. Submittals shall be in accordance with Section 01300 – Submittals and shall include plans and procedures for handling flood flows and dewatering excavations. Submit plans and procedures to Engineer for approval.

B. Any construction modifications to the system shall also be submitted.

1.3 JOB CONDITIONS

Approval of plans and procedures for handling flood flows and dewatering does not relieve the Contractor of full responsibility and liability for care of water during construction.

PART 2 PRODUCTS

[Not Used]

PART 3 EXECUTION

3.1 FLOOD FLOWS AND OTHER WATER

The Contractor shall be responsible for handling and diverting any flood flows, stream flows, or any other water, including groundwater encountered during the progress of the work. Build, maintain, and operate cofferdams, channels, flumes, sumps, and other temporary works needed to pass floodwater, divert stream flow, or pass other surface water through or around the construction site and away from construction in progress. Unless otherwise approved by the Engineer, a diversion must discharge into the same natural watercourse in which its headworks are located. Construct permanent work in areas free from water. The removal of protective works, after having served their purpose, shall be in a manner satisfactory to the Engineer.

## 3.2 SURFACE RUNOFF

Surface runoff water shall be diverted away from the trenches. Such diversion shall be into existing drainage structures such as storm sewers, ditches or streams. Diversion of surface runoff shall be in such a manner to prevent flooding of or damage to public or private property.

## 3.3 DEWATERING EXCAVATED AREAS

A. The Contractor shall be responsible for dewatering all excavations during construction. Lower the water table as needed to keep those areas free of standing water or excessive muddy conditions.

B. Furnish the drains, sumps, casings, well points, and other equipment necessary to dewater areas for required construction work. Any dewatering method that causes a loss of fines from foundation areas will not be permitted. Keep available standby equipment to provide proper and continuous operation of the dewatering system. Provide continuous monitoring (24 hours per day) of the dewatering system to provide continuous operation.

## 3.4 DEWATERING TRENCHES & BORE PITS

Dewatering of trenches and bore pits shall be accomplished by whatever means elected by the contractor. However, bedding material or pipe may not be placed in wet or unstable trenches. Soil that cannot be properly dewatered shall be excavated and dry material tamped in place to such a depth as may be required to provide a firm trench bottom.

The Contractor shall be responsible for furnishing whatever materials are required and performing whatever work is necessary to provide a stable bottom in the trench. If the bottom of the trench is wet and unstable, the Contractor may cut a small ditch at the side of the trench bottom and drain off water to a sump from which it is pumped from the ditch. Wet unstable material in the trench bottom may be excavated and replaced with dry sandy material. The trench bottom shall be kept dry while pipe is being laid and until it is covered with sufficient backfill to prevent flotation of the pipe. The Contractor may install a well pointing system to dewater the trench if He so chooses, however, the cost for well pointing or other means of trench dewatering shall be considered subsidiary to the cost of installing the pipe and no additional payment shall be made for dewatering measures.

In areas where the trench bottom is unstable due to groundwater or other conditions and stability cannot be obtained by the methods listed above, the Contractor shall undercut the trench as necessary and stabilize it with crushed rock meeting the requirements for embedment for pipe. Undercutting and installation of crushed rock shall be not be used until approval is obtained from the Engineer of Owner through the field Project Representative. Crushed rock for stabilization shall be used only when absolutely necessary. Payment for undercut and addition of crushed rock for stabilization shall be made by the truck cubic yard of material used for stabilization as evidenced by “trip tickets” for the delivered materials. This payment item is not to be used to compensate the Contractor for the crushed rock embedment required for the

water line installation and is to be used solely for trench and bore pit stabilization when required.

END OF SECTION

SECTION 02314

# PIPELINES CROSSING HIGHWAYS, STREETS AND RAILROADS BY BORING OR OPEN CUT

## PART 1 GENERAL

### 1.1 WORK INCLUDED

Furnish labor, materials, equipment and incidentals necessary to install pipe casings by boring, or open cut as specified. This section sets forth the requirements for utility lines crossing roadways or railroads using bore, or open cut methods.

### 1.2 QUALITY ASSURANCE

A. Installer's Qualifications

Installation shall be by a competent, experienced contractor or sub-contractor. The installation contractor shall have a satisfactory experience record of at least three (3) years engaged in similar work of equal scope.

B. Performance Requirements

Lateral or vertical variation in the final position of the pipe casing from the line and grade established by the Engineer shall be acceptable only to the extent that it does not impact the line and grade of the carrier pipe shown on the Drawings.

### 1.3 SUBMITTALS

Submittals shall be in accordance with Section 01300, SUBMITTALS and shall include:

A. Product data sheet on casing pipe

B. Product data sheet on end seals

C. Provide shop drawings of casing insulators including sketches of insulators with material components and dimensions and proposed locations of insulators

D. Provide description of equipment used for boring

E. List of projects showing contractor has at least three years of satisfactory experience engaged in similar work of equal scope

F. Provide welding certification for all welders on the project

G. Mix design for any cement mortar or pressure grout

### 1.4 STANDARDS

| | |
|---|---|
| AWWA C-206 | “Field Welding of Steel Water Pipe" |
| AWWA C-210 | "Liquid Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines" |
| AASHTO M-190 | "Bituminous Coated Corrugated Metal Culvert Pipe and Pipe Arches" |
| AASHTO | Standard Specifications for Highway Bridges, 1989. |
| ASTM A-36 | "Structural Steel" |
| ASTM A-123 | "Zinc (Hot Dipped Galvanized) Coatings on Iron and Steel Products" |
| ASTM A-135 | "Electric - Resistance - Welded Steel Pipe" |
| ASTM A-139 | "Electric - Fusion (Arc) - Welded Steel Pipe" |
| ASTM A-153 | "Zinc Coating (Hot Dip) on Iron and Steel Hardware" |
| ASTM A-307 | "Carbon Steel Bolts and Studs, 60,000 PSI Tensile" |
| ASTM A-449 | "Quenched and Tempered Steel Bolts and Studs |
| ASTM A-569 | "Steel, Carbon, Hot-Rolled Sheet and Strip, Commercial Quality" |
| ASTM A-570 | "Hot Rolled Carbon Steel Sheet and Strip, Structural Quality" |
| ASTM C-76 | "Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe" |
| ASTM D-4254 | "Test Methods for Minimum Index Density of Soils and Calculation of Relative Density" |

1.5 JOB CONDITIONS; PERMITS AND EASEMENT REQUIREMENTS

A. Where the work is in the public right-of-way or TxDOT company right-of-way, the Owner will secure the appropriate permits or easements. The Contractor shall observe regulations and instructions of the right-of-way Owner as to the methods of performing the work and take precautions for the safety of the property and the public. Negotiations and coordination with the right-of-way Owner shall be carried on by the Contractor, not less than five (5) days prior to the time of his intentions to begin work on the right-of-way or as required by the Owner's permit.

B. Comply with the requirements of the permit and/or easement, a copy of which is included in the Attachments. The work within Texas Department of Transportation (TxDOT) shall comply with TxDOT specifications. If required by the rights-of-way Owner, obtain Protective Liability Insurance in the amount required by the particular company or other insurance as is specified in the permit at no cost to the Owner. Acquire a permit, agreement, or work order from the right-of-way Owner as is required.

C. Construction along roads and railroads shall be performed in such manner that the excavated material be kept off the roads and railroads at all times, as well as, all operating equipment. Construction shall not interfere with the operations of the roads and railroads.

D. Barricades, warning signs, and flagmen, when necessary and specified, shall be provided by the Contractor.

E. No blasting shall be allowed. Existing pipelines are to be protected. The Contractor shall verify location and elevation of any pipelines, telephone cable, and other utilities before proceeding with the construction and plan his construction so as to avoid damage to the existing pipelines, telephone cables, or utilities. Verification of location of existing utilities shall be the complete responsibility of the Contractor.

1.6 OPTIONS

A. Casing Material

The Contractor shall use steel pipe for all casing pipe. The material specification for casing pipe are the minimum acceptable. The Contractor shall be fully responsible to insure the materials used are of sufficient strength for the installation method chosen and the soil conditions encountered.

B. Bore Methods

If specified on the drawings, the Contractor may use boring and jacking for the installation method of casing material. The Contractor shall be fully responsible to insure the methods used are adequate for the protection of workers, pipe, property, and the public. Provide a finished product as required.

PART 2 PRODUCTS

2.1 MATERIALS

A. Steel Pipe: Steel casing pipe shall have a minimum yield strength of 35,000 psi. Casing shall meet ASTM A-36, ASTM A-570, ASTM A-135, ASTM A-139, or approved equal. Pipe joints shall be welded in accordance with AWWA C-206. Unless specified otherwise, the minimum wall thickness of steel casing pipe shall be as follows:

| Casing Diameter | Wall Thickness |
|---|---|
| <12” | 0.25" |
| 12" - 20" | 0.375" |
| >20” | 0.50" |

2.2 MIXES

A. Cement Mortar: Consisting of one (1) part cement to two (2) parts clean sand with sufficient water to make a thick workable mix.

B. Pressure Grout Mix: Comprised of 1 cubic foot of cement and 3.5 cubic feet of clean fine sand with sufficient water added to provide a free flowing thick slurry. If

desired to maintain solids in the mixture in suspension, one cubic foot of commercial grade bentonite may be added to each 12 to 15 cubic feet of the slurry.

## 2.3 MANUFACTURED PRODUCTS

A. Casing Insulators:
1. Use casing insulators for all types of carrier pipe.
2. Insulators shall consist of pre-manufactured steel bands with plastic lining and plastic runners.
3. Insulators shall fit snug over the carrier pipe and position and restrain the carrier pipe in the center of the casing pipe, to provide adequate clearance between the carrier pipe bell and the casing pipe.
4. Fasteners for insulators shall be stainless steel.
5. Insulators shall be as manufactured by Advanced Product and Systems, Inc., Model #SSI, or Engineer approved equal.

B. End Seals:
1. All casing ends shall be sealed.
2. Seals for carrier pipe under 18" shall be one-piece rubber with stainless steel bands.
3. End seal shall be molded to fit the casing pipe and carrier pipe.
4. End seals shall be as manufactured by Advanced Product and Systems, Model #AC or Engineer approved equal.

# PART 3 EXECUTION

## 3.1 GENERAL CONSTRUCTION PROCEDURES

A. Excavation And Backfill Of Access Pits

1. Do not allow excavation over the limits of the bore as specified. Trench walls of access pits adjacent to the bore face shall be truly vertical. Shore the trench walls as necessary to protect workmen, the public, structures, roadways, and other improvements.

2. Excavations within the right-of-way and not under surfacing shall be backfilled and consolidated by tamping in 6" horizontal layers to 95% of maximum density as measured by ASTM D-698. Surplus material shall be removed from the right-of-way and the excavation finished to original grades. Backfill pits immediately after the installation of the carrier pipe is completed. If carrier pipe is not installed immediately after casing pipe installation, the Right-of-Way Owner may require the access pits be temporarily backfilled until installation of carrier pipe.

3. Where seeding or sodding is disturbed by excavation or backfilling operations, such areas shall be replaced by seeding or sodding as specified.

B. Installing Carrier Pipe In Casings

1. Pipe to be installed within the casing shall meet the requirements for the type of pipe as specified. Where indicated, place, align, and anchor guide rails and/or casing insulators inside the casing. If guide rails are used, place cement mortar on both sides of the rails.

2. Pull or skid pipe into place inside the casing. Lubricants such as flax soap or drilling mud may be used to ease pipe installation. Do not use petroleum products, oil or grease for this purpose. If guide rails are used, install pipe and hold down jacks after installation of carrier pipe.

3. After installation of the carrier pipe, mortar inside and outside of the joints as applicable.

4. After carrier pipe installation is complete, seal or plug the ends of the casing.

C. Free-Air System

If required by OSHA standards, free-air systems shall be installed and maintained.

D. Installation Of Pressure Grout Mix

1. Install pressure grout mix in the void space between the outside of the casing pipe and the excavation. For bore or jacks with casing pipe, install pressure grout mix immediately upon completion of setting casing pipe.

## 3.2 CROSSINGS INSTALLED BY BORING

A. Dry Bore (Auger Method)

1. Perform the boring from the low or downstream end unless specified otherwise. Bore the holes mechanically using continuous flight auger. The casing bore shall not be performed by directional drilling unless approved by the Engineer prior to bidding. Place excavated material near the top of the working pit and dispose of material as required.

2. In unconsolidated soil formations, a gel-forming colloidal drilling fluid consisting of at least 10% of high grade carefully processed bentonite may be used to consolidate cuttings of the bit, seal the walls of the hole, and furnish lubrication for subsequent removal of cuttings and installation of the pipe immediately thereafter.

3. In locations where the soil formation is other than consolidated rock, insert the casing pipe simultaneously with the boring operation. This requirement applies to all bored holes of 18" or greater in diameter. For smaller diameter bored holes, it is desirable that the casing be installed as the boring progresses, but because of differences in soil formations, the time for inserting the casing shall be the Contractor's responsibility. In the event that caving sand or water bearing materials are encountered, insert the casing pipe simultaneously with the boring operation regardless of the diameter of the bored hole. In all cases, the security and integrity of the roadway is the primary concern. The Contractor shall be held fully responsible for the continued integrity of the structure of the roadway being crossed, whether or not a casing pipe is inserted simultaneously with the boring operation.

H. Wet Bore (Horizontal Directional Drilling)

1. Perform the boring from the low or downstream end unless specified otherwise. Bore the holes mechanically and use a pilot hole.

2. By this method, an approximate 2" pilot hole shall be bored the entire length of the crossing and shall be checked for line and grade.

3. This pilot hole shall serve as the centerline of the larger diameter hole to be bored. The casing bore shall be by reamer pulled back through the 2” pilot hole. Reamer diameter shall be of the same diameter as the pipe material being installed.

4. Place excavated material near the top of the working pit and dispose of material as required.

5. The use of water or other fluids in connection with the boring operation will be permitted only to the extent to lubricate cuttings.

6. Jetting shall not be permitted.

7. In unconsolidated soil formations, a gel-forming colloidal drilling fluid consisting of at least 10% of high grade carefully processed bentonite may be used to consolidate cuttings of the bit, seal the walls of the hole, and furnish lubrication for subsequent removal of cuttings and installation of the pipe immediately thereafter.

8. In locations where the soil formation is other than consolidated rock, insert the casing pipe simultaneously with the reaming operation. This requirement applies to all reamed holes of 18" or greater in diameter. For smaller diameter reamed holes, it is desirable that the casing be installed as the reaming progresses, but because of differences in soil formations, the time for inserting the casing shall be the Contractor's responsibility. In the event that caving sand or water bearing materials are encountered, insert the casing pipe simultaneously with the reaming operation regardless of the diameter of the bored hole. In all cases, the security and integrity of the roadway is the primary concern. The Contractor shall be

held fully responsible for the continued integrity of the structure of the roadway being crossed, whether or not a casing pipe is inserted simultaneously with the reaming operation.

## 3.3 CROSSINGS WITH CASING INSTALLED BY OPEN CUT

This article covers the requirements for the construction of crossings where pipe casing is required for installation by the open cut method. Excavation, backfill, and embedment of casing pipe shall be as specified. Casing shall be bedded in gravel material to the springline of the casing. Contractor shall backfill with select fill material compacted in 8-inch lifts to 95% STD Proctor. Contractor shall complete the backfill and repair the surface as shown. If settlement under pavement occurs, the pavements shall be removed and the trench recompacted at the Contractor's expense.

END OF SECTION

SECTION 02610

FIBERGLASS REINFORCED POLYESTER (FRP) WET WELL

PART 1 GENERAL

1.1 SCOPE

A. This specification shall govern for the furnishing of all work necessary to accomplish and complete the installation of glass-fiber reinforced polyester wet wells. Glass-Fiber Reinforced Polyester wet wells shall be a **one-piece monolithic designed unit constructed of glass-fiber reinforced, supplier certified, unsaturated commercial grade polyester resin containing chemically enhanced silica to improve corrosion resistance, strength and overall performance.**

B. Furnish all labor, materials, equipment and incidentals to provide new fiberglass reinforced polyester (FRP) wet wells.

1.2 REFERENCES

Wet wells shall conform to the following design criteria:

A. ASTM D-3753: Standard Specification for Glass-Fiber Reinforced Polyester Manholes and Wet wells.

B. ASTM C-581: Practice for Determining Chemical Resistance of Chemical Thermosetting Resins Used in Glass-Fiber Reinforced Structures Intended for Liquid Service.

C. ASTM D-2412: Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel Plate Loading.

D. ASTM D-695: Test Methods for Compressive Properties of Rigid Plastics.

E. ASTM D-2584: Test Method for Ignition Loss of Cured Reinforced Resins.

F. ASTM D-790: Test Method for Flexural Properties of Unreinforced and Reinforced Plastics and electrical Insulating Materials.

G. ASTM D-2583:Test Method for Indentation Hardness of Rigid Plastics by means of a Barcol Impressor.

1.3 SUBMITTALS

A. Submit under provisions of Section 01300.

B. Shop Drawings: Manufacturer's literature and drawings prepared for this project showing types, sizes, pertinent dimensions, FRP thickness, finish, complete details of construction, anchorage, fastenings, bracing, closure method, coordination with hardware, appurtenances and installation details for units.

C. Quality Control Submittals:

1. Manufacturer's Installation Instructions.

2. Manufacturer's Instructions for Handling and Care of Products.

3. Manufacturer's Certification that product furnished meets or exceeds requirements specified herein.

1.4 QUALIFICATIONS

A. Manufacturer: Company specializing in manufacturing products specified in this section with minimum three years documented experience.

B. No "or equals" or substitute products will be considered unless they meet all of the specification requirements and are approved by the Engineer.

1.5 QUALITY ASSURANCE/QUALITY CONTROL

A. Examination: Each FRP cylinder component part shall be examined for dimensional requirements, hardness and workmanship.

B. Composition Control: Controls on glass and resin content shall be maintained for all manufacturing processes and for each portion of the FRP cylinder fabrication. Records shall be maintained of these control checks. Proper glass content my be shown by glass usage checks, by glass and resin application rate checks, in accordance with the material composition test in ASTM D 3753, Section 8.8.1.

C. All required ASTM D-3753 testing shall be completed and records of all testing shall be kept and copies of test results shall be presented to customer upon written request within a reasonable time period.

PART 2 PRODUCTS

2.1 FRP Wet Wells

A. Dimensions: The wet wells shall be a circular cylinder, sized per the plans for the applicable stations. Wet wells shall be produced in per the length in the plans +/- Y," Nominal inside diameters shall be 36", 42", 48", 54", 60", 66", 72", 92", 120", 132", 168", 186", 192", 216", and 240". Tolerance on the inside diameter shall be +/- 1%. Other diameters as agreed upon between purchaser and the manufacturer are covered by this specification.

B. The manufacturer of the wet well shall be able to show experience in the manufacture of FRP wet wells for more than five years.

C. Design Criteria:

1. Wet wells shall meet all requirements for pipe stiffness as required in ASTM D3753.

2. The wet wells shall be suitable for use in typical environments including storm and sanitary sewers with a temperature range of -40o F. to 150o F.

3. Cylinders shall be designed and fabricated to provide sufficient strength for the following loading conditions:

a). Resistant to buckling when empty and when the groundwater elevation is at grade.

b). The anchoring wall structure at the embankment within the reinforced concrete base zone shall be designed to resist external hydrostatic water forces of an empty or full cylinder with the groundwater at grade elevation.

c.) Load Bearing Capacity: Properly installed wet well shall be capable of withstanding AASHTO HS-20 dynamic loading (16,000 lbs.) applied vertically.

4. The FRP wet wells, shall be manufactured to the diameters and heights as shown in the plans and specifications. They shall be designed by the manufacturer to perform as underground structures at the depths required. The FRP structures shall be capable of supporting the top slab covers, frames, soil overburdens plus a live load equivalent to AASHTO HS-20 Loading.

5. All cutouts shown in the plans and details for each FRP wet well shall be capable of maintaining the unit's structural integrity.

6. Wet well FRP Tops and Hatch Openings: Resin and glass fiber reinforced wet well tops and hatch openings may be provided upon Engineers request. Wet wells shall be provided with glass reinforced top designed to withstand backfill and concrete slab. Fiberglass Ribs or Fiberglass structural members may be utilized to meet the design criteria. **Stiffeners shall be of non- corrosive materials encapsulated in fiberglass. FRP encapsulated wood or lumber shall not be permitted.**

a). Hatch opening dimensions and position to be specified by Engineer.

b) Vapor barrier lip around hatch opening shall be 4" tall. It shall be shall be constructed of fiberglass pultruded structural shapes.

7.Wet well FRP Bottoms: Resin and glass fiber reinforced wet well bottoms may be provided upon Engineers request. Upon that request, wet wells shall be provided with glass reinforced bottom section designed to withstand the hydrostatic head pressure, empty and water to grade, of units at 25-ft. burial depth. (Units deeper than 25 ft may require additional reinforcement as required). Fiberglass Ribs or Fiberglass structural members may be utilized to meet the design criteria. **Stiffeners shall be of non-corrosive materials encapsulated in fiberglass. FRP encapsulated wood or**

**lumber shall not be permitted.** Bottoms sections shall be furnished with an intregal 3" wide anchoring flange.

8. Wet well FRP bottom or top flanges: Resin and glass fiber reinforced wet well flanges may be provided upon Engineers request. Flanges shall be 3" wide minimum.

D. Marking and Identification: All Wet wells shall be marked with the following information:

1) Manufacturers Identification

2) Manufacturers Serial Number

3) Wet well Diameter & Length

4) ASTM Designation

2.2 MATERIALS

A. Resin: The resins used shall be unsaturated, supplier certified, commercial grade polyester resins. **Mixing lots of resin from different manufacturers or "odd-lotting" of resins shall not be permitted.** Quality-assurance records on the resin shall be maintained. Non-pigmented Resin is required to allow for light or "sand" color of manhole surface in order to facilitate easy from grade interior inspection. **UV Inhibitors shall be added directly to resins to prevent photodegradation.**

B. Reinforcing Materials: The reinforcing materials shall be commercial grade "E" type glass in the form of mat, continuous roving, chopped roving, roving fabric, or both, having a coupling agent that will provide a suitable bond between the glass reinforcement and the resin.

C. Surfacing Material: If reinforcing material is used on the surface exposed to the contained substance, it shall be a commercial grade chemical-resistant glass or organic surfacing mat having a coupling agent that will provide a suitable bond with the resin.

D. Fillers and Additives: Fillers, when used, shall be inert to the environment and manhole construction. Additives, such as thixotropic agents, catalysts, promoters, etc., may be added as required by the specific manufacturing process to be used to meet the requirements of this standard. However, calcium carbonate mixed by the fabricator shall not be permitted. The resulting reinforced plastic material must meet the requirement of this specification.

E. Laminate: The laminate shall consist of multiple layers of glass matting and resin. The surface exposed to the sewer/chemical environment shall be resin rich and shall have no exposed fibers.

2.3 MANUFACTURE

A. Wet well cylinders, flat tops and flat bottoms, shall be produced from glass fiber-reinforced polyester resin. Wet well cylinders to 72" ID to be manufactured by "computer regulated mandrel process", 72" ID and larger to be manufactured by computer regulated steel mandrel process utilizing structural rib design.

B. Assembly Joints: Product components, i.e., cylinders, tops, bottoms, and connectors, may be joined together to form a complete wet well.

2.4. REQUIREMENTS

A. Exterior Surface: The exterior surface shall be relatively smooth with no sharp projections. Hand- work finish is acceptable if enough resin is present to *eliminate* fiber show. The exterior surface shall be *free of blisters* larger than 0.5" in diameter, delamination and fiber show. **Gel-coat or paint or other coatings are not allowed.**

B. Interior Surface: The interior surfaces shall be resin rich with no exposed fibers. Interior surface shall be smooth for improved corrosion resistance and reduced sludge build-up. The surface shall be free of crazing, delamination, blisters larger than 0.5" in diameter, and wrinkles of 0.125" or greater in depth. Surface pits shall be permitted up to 6/ft2 if they are less than 0.75" in diameter and less than 0.0625" deep. Voids that cannot be broken with finger pressure and that are entirely below the resin surface shall be permitted up to 4/ft2 if they are less than 0.5" in diameter and less than 0.0625" thick. **Gel-coat or paint or other coatings are not allowed.**

C. Repairs: Any wet well repair is required to meet all requirements of this specification.

D. Wet well Lengths: Wet well lengths shall be as shown in the plans (+/-).

E. Stiffness: The cylindrical portion of the wet well is to be tested in accordance with ASTM Method D 2412. The wet well cylinder shall have the *minimum* pipe-stiffness values shown in the table below, when tested in accordance with ASTM 3753, Section 8.5, (note 1).

| Wet well Length (ft) | PSI |
|---|---|
| 3 - 6 | 0.72 |
| 7 - 12 | 1.26 |
| 13 - 20 | 2.01 |
| 21 - 25 | 3.02 |
| 26 - 35 | 5.24 |

G. Chemical Resistance: Per ASTM C 581; (see ASTM 3753, Section 8.7), Flexural strength, flexural modulus, and barcol hardness are plotted versus time on log-log coordinates. The line defined by these points is extrapolated to 100,000 hours. The minimum extrapolation retention allowed for any of these properties is 50%. Test samples used are actual pieces of wet well or samples manufactured in a manner consistent in every way with the wet well component construction.

Physical Properties:

| | |
|---|---|
| Flexural Strength (pipe) | Hoop: 22.5 x 103 psi |
| | Axial: 14.3 x 103 psi |
| Compressive Strength: | 8.9 x 103 psi |

2-5 TEST METHODS

A. All tests shall be performed as specified in ASTM 3753, Section 8, Titled "Test Methods". See ASTM 3753, Section 8, Note 5, for Test method D-790 and test method D-695.

2-6 CERTIFICATIONS

A. When requested by the purchaser on his order, a certification shall be made the basis of acceptance. This shall consist of a copy of the manufacturer's test report or a statement by the supplier, accompanied by a copy of the test results, that the manhole has been sampled, tested, and inspected in accordance with the provisions of ASTM 3753 and this specification, and meets all requirements. An authorized agent of the supplier or manufacturer shall sign each certification so furnished.

PART 3 EXECUTION

3.1 INSPECTION

A. The quality of all materials, the process of manufacture, and the finished sections shall be subject to inspection and approval by the Engineer, or other representative of the owner. Such inspections shall be made at the place of manufacture, or at site of delivery, and the sections shall be subject to rejection on account of failure to meet any of the specification requirements as specified herein. Sections rejected after delivery to the job site shall be marked for identification and shall be removed from the job at once. All sections which have been damaged after delivery will be rejected, and if already installed shall be acceptable if repaired or removed and replaced at the contractor's expense.

B. At the time of inspection the material will be examined for compliance with the requirements of this specification and the approved drawings.Verify that wet well comply with approved shop drawings and meet the indicated requirements for type, size, and location.

3.2 INSTALLATION

A. Each excavation and backfill are to be done as part of the work under this section, including any necessary sheeting and bracing. The contractor shall be responsible for handling groundwater to provide firm, dry subgrade for the structure, shall prevent water from rising on new poured in place concrete within 24 hours after placing, and shall guard against flotation of other damages resulting from groundwater or flooding.

B. A minimum of 12-in. bedding shall be placed as a foundation for the wet well base slabs.

C. Backfilling: Do not backfill until concrete base has hardened sufficiently to provide rigid support for both the wet well and backfill. Add backfill evenly in 12" lifts all around wet well to avoid uneven backfill loads. 90% compaction of backfill is required in order to prevent settlement of connecting pipes and to provide sidewall support to the wet well.

D. The Cast-in-place concrete base shall be placed on a thoroughly compacted sub-base. The bottom of the FRP sections shall be cast-in-place a minimum of 4 inches and shall be adjusted in grade so that the top slab section is at elevation specified in the contract or on approved drawings.

E. Pre-cast concrete bases are permitted with Engineer pre-approval for installation with the wet well. If such bases are used and are to be set with the wet well, all lifting shall be done on the base itself with Engineer approved lifting eyes or loops and not the wet well structure.

F. The FRP manufacturer's written installation instructions shall be followed to ensure the wet well will perform in accordance with the design requirements of the applicable specification.

G. Wet well cutouts may be made in the FRP wet well, using a circular saw, saber saw, hole saw, or similar equipment with a masonry type blade. Axes, hammers, chisels, or similar impact type tools may not be used.

H. Stubouts and Connections: All FRP inserts and FRP sleeves for piping shall be made as shown on installation drawings and in accordance with the manufacturer's FRP specifications for installation. Other methods of connections may be performed per Engineers request or as shown in the plans and specifications, i.e., Inserta-Tee fittings, pipe connectors which conform to ASTM C-923 or PVC sewer pipe with FRP lay-up reinforcement installed per manufacturer's recommendation.

1). Inserta-Tee Fittings: Joints for sewer pipe line and drop connections sizes 4" - 15" shall be made by means of Inserta-Tee watertight compression connection. Installation shall be in strict accordance with manufacturer's written instructions utilizing installation equipment approved for use by the manufacturer of the Inserta-Tee fitting. Use of equipment which does not meet this requirement is expressly prohibited. Inserta-Tee Fitting a product of Inserta Fitting Co., Hillsboro, OR.

2). Pipe Stubouts:

a). Install rubber gasketed PVC sewer pipe stubouts to wet well with resin and glass-fiber reinforced lay-up. Gaskets shall meet the same performance requirements of the sewer pipe to be installed unless otherwise directed by Engineer. Resin and glass shall be of the same type and grade as used in the fabrication of the FRP wet well.

b). Install PVC or FRP pipe stubouts for use with resilient pipe-to-wet well connectors (boots) which conform to the performance requirements of ASTM C-923. PVC or FRP pipe stubouts may also be used by placing incoming service piping through stubout and sealing the annular space with expandable sealing mechanism, such as "Inter-Lynx". Inter-Lynx is a product of Advanced Products and Systems, Inc., Lafayette, LA.

3.3 DELIVERY, STORAGE AND HANDLING

A. FRP wet wells shall be lifted by the installation of lifting lugs as specified by the manufacturer on the outside surface near the top of the wet well. Wet wells may also be lifted in the horizontal position with two slings on a spreader bar.

B. FRP wet wells may be stored upright or horizontally, however, the wet well vertical deflection shall not exceed 4% of the diameter. The wet well shall not be dropped or impacted.

C. Additional handling and installation instructions shall be in accordance with the FRP manufacturer's instructions.

D. Each FRP section manufactured in accordance with the drawings shall be clearly marked to indicate the intended pump station installation location. The contractor shall be responsible for the installation of the correct FRP sections in their designated pump station locations.

PART 4 - MEASUREMENT AND PAYMENT

A. MEASUREMENT

This item will be measured by each type of individual structure completed. The depth will be measured from the flow line to the top of the rim. The size shall be nominal inside diameter. This item includes, but is not limited to the following:

1. Structural excavation

2. Loading, hauling, and disposing of all excess material

3. Furnishing all labor and materials including fiberglass, concrete, mortar, bricks, drop pipe and fittings, manhole rings and covers

4. Placing and compacting all backfill

5. Final Grading

B. 3.5 PAYMENT

This item will be paid at the contract unit price per each structure for the various sizes, types, and various depths of structures complete in place and will be full compensation

for all materials required, operations, labor, tools, equipment, and all other incidentals necessary to complete the work as shown on the plans and specified herein.

END OF SECTION

SECTION 02665

WATER SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Pipe and fittings for water lines including, supply lines, and potable water distribution lines.

B. Fire hydrants, fittings, and appurtenances.

1.2 RELATED SECTIONS

A. Section 01300 – Submittals.

B. Section 01400 – Quality Control.

C. Section 01600 – Material and Equipment.

D. Section 02205 – Soil Materials.

E. Section 02207 – Aggregate Materials.

F. Section 02225 – Excavation, Backfill, and Compaction for Utilities.

G. Section 02675 – Disinfection of Water Distribution Systems.

H. Section 03305 – Concrete.

1.3 REFERENCES

A. American Society for Testing and Materials (ASTM)

A. ASTM A126 – Gray Iron Castings for Valves, Flanges and Pipe Fittings.

B. ASTM A307 – Specification for Carbon Steel Bolts and Studs 60,000 psi Tensile.

C. ASTM A536 – Ductile Iron Castings.

D. ASTM B88 – Seamless Copper Water Tube.

E. ASTM D698 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort.

F. ASTM D1784 – Standard Specification for Rigid PVC Compounds and Chlorinated PVE Compounds.

G. ASTM D1785 – Polyvinyl Chloride (PVC) Plastic Pipe, Schedules 40, 80, and 120.

H. ASTM D2241 – Standard Specifications for Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series).

I. ASTM D2464 – Polyvinyl Chloride (PVC) Plastic Pipe Fittings, Schedule 80.

J. ASTM D2466 – Standard Specifications for Poly (Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40 (SDR Series).

K. ASTM D2467 – Polyvinyl Chloride (PVC) Plastic Pipe Fittings, Schedule 80.

L. ASTM D2837 – Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials

M. ASTM D2855 – Making Solvent-Cemented Joints with Polyvinyl Chloride (PVC) Pipe and Fittings.

N. ASTM D2922 – Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).

O. ASTM D3017 – Standard Test Methods for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).

P. ASTM D3139 – Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals.

Q. ASTM F477 – Elastomeric Seals (Gaskets) for Joining Plastic Pipe.

B. American Water Works Association (AWWA)

A. AWWA C105

B. AWWA C110 – Ductile-Iron and Gray-Iron Fittings, 3 inches through 48 inches, for Water and Other Liquids.

C. AWWA C111

D. AWWA C150

E. AWWA C151

F. AWWA C153 – Ductile Iron Compact Fittings, 3 inches through 12 inches, for Water and Other Liquids.

G. AWWA C502 – Dry-Barrel Fire Hydrants

H. AWWA C511

I. AWWA C600

J. AWWA C900 – Polyvinyl Chloride (PVC) Pressure Pipe, 4 inches through 12 inches, for Water.

K. AWWA C901 – Polyethylene (PE) Pressure Pipe, Tubing, and Fittings, ½ inch through 3 inches for Water.

L. AWWA C905.

C. National Sanitation Foundation (NSF)

A. NSF14 – Plastic Piping System Components and Related Materials.

B. NSF61 – Drinking Water System Components – Health Effects.

D. American National Standards Institute (ANSI).

A. ANSI B16.9 – Fittings.

B. ANSI B36.19 – Wall Thickness.

C. ANSI A21.11/AWWA C111 – Mechanical Joints.

D. ANSI B16.1 – Flanges and Flanged Fittings.

E. Texas Administrative Code, Volume 30, Chapter 290, Water Hygiene.

1.4 SUBMITTALS

A. Procedures for Submittals: Section 01300.

B. Product Data: Manufacturer's product data sheets on all materials incorporated into work.

C. Quality Control Submittals: For information only.

1. Certificates: Manufacturer's certificates attesting compliance with applicable specifications for grades, types, classes, and other properties.

2. Test Reports: Results of field quality control tests including hydrostatic tests and bacteriological tests.

D. Contract Closeout Submittals: Refer to Section 01700.

1. Protect Record Documents: Submit documents in accordance with Section 01700. Accurately record installed location of valves, hydrants, piping and service connections, and accessories.

1.5 QUALITY ASSURANCE

A. Pipeline installation shall be in accordance with manufacturer's recommendations and as supplemented by these specifications.

B. Pipe shall be kept clean of all foreign matter.

C. Jointing shall be by trained employees.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle products under provisions of Section 01600.

B. Each load of pipe delivered to the job site shall be inspected by the Engineer.

3. Pipe transported without adequate protection shall be rejected and removed immediately from the job site.

4. Inadequate wall thickness or tolerances greater than specified: Randomly selected samples of the pipe shall be forwarded

immediately to an approved testing laboratory with instructions to check the pipe for compliance with applicable product standards, ASTM Specifications, and other applicable specifications.

5. When the testing laboratory reports concur that the pipe does not meet specifications, the defective pipe shall be removed immediately from the job site by the Contractor.

6. If defective, all costs for shipping of samples, laboratory testing, removal of defective pipe, and replacement pipe shall be the sole responsibility of the Contractor.

PART 2 PRODUCTS

2.1 PIPE

A. Ductile Iron Water Pipe

A. All ductile iron water pipe shall be in accordance with ANSI/AWWA C150/A21.50 and ANSI/AWWA C151/A21.51.

B. Ductile iron water pipe shall be at least 150 pressure class.

C. All pipes shall bear the NSF Seal of Approval.

D. Interior surfaces shall be cement lined per AWWA C104.

E. Exterior surfaces shall be coated with bituminous coating per AWWA C110.

F. Pipe shall be free from excessive pits, scars, or other surface defects.

G. Joints shall be integral bell with flexible elastomeric seal per AWWA C111.

H. Install pipe as specified in AWWA C600.

I. All ductile iron pipe, fittings, and appurtenances shall be wrapped in eight mil polyethylene tubing and tape encasement per AWWA C105.

J. All flanged ductile iron pipe shall meet AWWA C115 with minimum thickness of Special Class 53.

K. Approved Manufacurers: American Cast Iron Company, McWane Pipe, U.S. Pipe and Foundry

B. PVC Water Pipe - AWWA C900 or AWWA C905 Restrained Joint

A. DR 18 – Pressure, Class 235.

B. All pipe shall bear NSF seal of approval.

C. Joints shall be integral bell with flexible elastomeric seal.

D. Approved Manufacurers: CertainTeed – Certa-Lok, Diamond Plastics, Jet Stream, JM Eagle, North American, Northern, Royal, Vinyletch.

## 2.2 FIRE HYDRANTS

A. Fire hydrants shall be 30-inch standard bury depth, post type, dry barrel, traffic model with 5-1/4 inch main valve, two 2-1/2 inch hose nozzles and one 4-1/2 inch pumper nozzle with National Standard Threads (NST). Hydrants shall be painted OSHA "Safety Yellow" and shall conform to AWWA C502 & C550.

B. Fire hydrant shall be Mueller Super Centurion A-423, American Darling B-84-B, Clow Medallion, East Jordan Iron Works WaterMaster, M & H 129.

C. Fire hydrant extensions must be of the same manufacturer and model as the hydrant they are being installed on. Standard extension sizes shall be 6", 12", 18", and 24". An extension above 24" will warrant replacement of the hydrant with an appropriate bury depth. No more than one extension per hydrant.Fire hydrant shall be painted per city color code.

E. Hydrants shall conform to AWWA C502 & C550.

## 2.3 FITTINGS

A. Fittings (two inches and larger in diameter)

A. Fittings shall be ductile iron according to AWWA C110 (full body) for fittings 2 inches in diameter and larger than 12 inches in diameter or AWWA C153 (compact) for fittings three inches through 12 inches in diameter.

B. Interior surfaces shall be cement lined in conformance with AWWA C104.

C. Exterior surfaces shall be bituminous coated in accordance with AWWA C104.

D. Fittings shall have mechanical joints with thrust restraint unless otherwise specified or shown. Any of the following are acceptable types and manufacturers of thrust restraining devices for the pipe types listed unless otherwise specified or shown on the plans. The method for thrust restraining all joints shall have a working pressure rating equal to or exceeding the pressure rating of the fitting which it restrains.

E. Pre-Approved Manufacturer

(a) American Cast Iron Pipe Company

(b) North American Cast Iron Products

(c) Tyler Union

(d) Sigma Corporation

(e) SIP

(f) Star Pipe Products

2.4 COUPLINGS

A. Supply couplings with a steel center band, steel gland rings, gaskets, and bolts; must conform to AWWA C219.

B. Couplings shall be rated for 1.25 times the maximum operating pressure of the line to be connected.

C. All couplings near bends, fittings, or valves shall be restrained with an Engineer approved mechanical restraint system.

D. Pre-approved Manufacturers

A. Dresser Industries.

B. Smith-Blair.

C. Ford

D. JCM

E. Romac

2.5 FLANGE ADAPTORS

A. Restrained flange adaptors shall be used in place of threaded or welded flange pieces only where specified or shown on the plans.

B. Restraint for the flange adaptor shall consist of a number of individual gripping wedges. Torque limiting actuating screws shall be used to insure proper initial set of the gripping wedges.

C. For PVC pipe, the flange adaptor shall have a pressure rating equal to that of the pipe. For ductile iron pipe, the flange adaptor shall have a safety factor of 2:1 minimum.

D. The flange adapter shall be the Series 2100 Megaflange adaptor as manufactured by EBAA Iron, Inc. or engineer approved equal.

2.6 BOLTS AND GASKETS

A. Gaskets shall be 1/16-inch cloth insert, red rubber, full face.

B. Bolts shall be in accordance with the following:

A. Non-Pressure Applications: ASTM A307A.

B. Pressure Applications: ASTM A307B.

C. Submerged/Splashed: 316 stainless steel.

2.7 PIPE SUPPORTS

Install adjustable pipe supports manufactured by Anvil International Inc. or Engineer approved equal as shown on the plans.

2.8 PRESSURE GAGUES

A. The gauges shall be as manufactured by Marshalltown Instruments, Ashcroft, Dresser Industries, Weksler, or approved equal and shall be the Manufacturer's standard commercial product. Gauge cases shall be phenol or ABC plastic, or steel zinc-coated or phosphate treated and finished with black enamel. Inlet shall be ¼" size with bottom connections.

B. Class 1 gauges shall be pressure-indicating. Class 2 gauges shall be vacuum gauge-designed for vacuum indications. Class 3 gauges shall indicate pressure or vacuum.

C. At each pressure gauge, furnish and install a pulsation dampener, Mid-West Model 150, Vari-Damp Pulsation Dampener, or approved equal.

D. Gauge cocks for isolating standard product gauges shall be heavy duty brass with tee handle and male and female ends for ¼" bottom threaded connections.

## 2.9 TAPPING SLEEVES

A. Sleeves shall be designed for a working pressure of at least 150 psi and furnished with a brass or stainless steel test plug through the body for hydrostatic pressure testing.

B. The outlet shall conform to ANSI B16.1, Class 125 flanges designed to accept tapping valves.

C. Sleeves shall be designed to properly fit the type and class of pipe on which they will be used. Sleeves may be cast iron, ductile iron, or welded steel.

D. Tapping sleeves, unless otherwise specified, shall be stainless steel or epoxy coated with stainless steel nuts and bolts.

E. Sleeves which are designed in such a manner that the watertight seal around the outlet is achieved by a gasket placed between the sleeve body and the pipe barrel shall be provided with a recess in the sleeve body to accommodate the gasket.

F. Sleeves shall conform to AWWA C207 and C228.

G. Approved manufacturers are: Ford Fast, Powerseal 3480AS, Romac SST, and Smith-Blair 663.

## 2.10 SERVICE LINES

A. Pipe

1. Polyvinyl Chloride (PVC) – 2-inch

2" PVC service line pipe shall be IPS Schedule 40 with glue type joints, Schedule 80 fittings, and shall conform to ASTM D1785.

Approved manufacturers are: Charlotte, Diamond, Jet Stream, JM Eagle, North American, Northern, Royal, Texas United

2. Copper Tubing (CT) – 1-inch

Copper tubing shall be domestic made, CTS, type K, soft, and conform to B88.

Pre-approved Manufacturers for Copper Tubing: Cambridge Lee, Cerro, Halstead, or Wieland.

B. Service Saddles

1. 2-inch

2" service saddles shall be bronze body, bronze double strap with bronze nuts, female iron pipe threaded outlet, and shall conform to AWWA C800.

Approved Manufacturers are: Ford 202-B, James Jones J-979, Mueller BR2B, and Romac 202-B.

2. 1-inch

1" service saddles shall be bronze body, bronze double strap with bronze nuts, female CC/AWWA taper threaded outlet, and shall conform to AWWA C800.

Approved Manufacturers are: Ford 202-B, James Jones J-979, Mueller BR2B, and Romac 202-B.

C. Service Valve

1. Brass Gate Valve – 2-inch

2" gate valved shall be brass body, full port, female iron pipe threaded inlet and outlet, non-rising stem with bronze hand wheel and NSF approval for potable water.

Approved Manufacturers are: Hammond, Milwaukee

2. Corporation Stop – 1-inch

1" corporation stops shall be no-lead bronze, full-port ball valve, 1" male AWWA/CC taper threaded inlet by 1" flared copper tube size outlet with nut, and shall conform to AWWA C800.

Approved Manufacturers are: Ford F-600-4NL, James Jones E-1500, McDonald 74701, Mueller H-15000N

3. Angle Stop – 1-inch

1" angle stops shall be no-lead bronze, 1" flared copper tube size inlet by 1-1/4" swivel meter coupling nut outlet with lockwing tee head, and shall conform to AWWA C800.

Approved Manufacturers are: Ford KV23-444W, James Jones J-1525, McDonald 4622, and Mueller H-14255.

## 2.11 TRACER WIRE FOR PVC PIPE

A. Tracer wire shall be 14-guage, HDPE-coated copper/steel wire manufactured for direct burial.

B. Approved Manufacturers are: Agave Wire, Copperhead, and Southwire.

2.12 DETECTABLE MARKING TAPE

A. Marking tape shall be 2-inch, color coded blue for water.

B. Approved Manufacturers are: Accucast, Presco, Pro-Line, and Terra Tape.

2.13 BACK FLOW PREVENTERS

A. Backflow preventers shall be of the reduced pressure principle type compliant with all provisions of AWWA C511.

B. Double Check, Double-Detector Check and Reduced Pressure Prevention Backflow Preventers shall have the American Society of Sanitation Engineering Seal of Approval and be installed as specified by TCEQ regulations.

C. Approved Manufacturers are: Ames, FebCO, Watts, and Wilkins.

PART 3 EXECUTION

3.1 PREPARATION

A. Inspect, unload, handle, and store materials as set forth in AWWA C600 and as specified.

B. Do not lay pipe in water, or when trench or weather are unsuitable for work. Keep water out of trench until jointing is complete and bedding is placed to top of pipe. When work is not in progress, close ends of pipe and fittings securely so that no trench water, earth or other substances will enter pipes or fittings.

C. Keep inside of pipe free from foreign matter during operations by plugging or other approved method.

D. Place pipe so that full length of each section rests solidly upon pipe bed, with recesses excavated to accommodate bells and joints. Take up and re-lay pipe when grade or joint is disturbed after laying.

E. Handle pipe and accessories so that pipe placed in trench is sound and undamaged. Take particular care not to injure pipe coating when applicable.

F. Cut neatly, using approved type mechanical cutter without damaging pipe. Use wheel cutters when practicable.

G. Install in locations sited with hangers, brackets, supports, etc., at spacings as recommended by pipe manufacturer.

H. Field cutting of stainless steel pipe will not be allowed.

3.2 PIPE BEDDING AND BACKFILL

A. Pipe Bedding and Backfill: In accordance with Section 02225 - Excavation, Backfilling, and Compacting for Utilities.

3.3 PLACING AND LAYING

A. Bury water lines as shown. The minimum cover for pipe four inches and less in diameter is 36 inches. The minimum cover for pipe larger than four inches in diameter is 48 inches.

B. Intersecting lines shall be joined by an appropriate fitting.

3.4 JOINTS

A. Install mechanical joints in accordance with the manufacturer's recommendations.

B. Make push-on joints in accordance with the manufacturer's recommendations.

C. Install solvent weld joints in accordance with ASTM D2855.

D. Joint lubricant shall be as recommended by the pipe manufacturer.

E. Install joints in the field by cleaning all joint surfaces and gaskets with soapy water, tighten bolts alternately, evenly and to the specified torques. Extension wrenches shall not be used to secure greater leverage. Install electrical bonding or insulation during installation of joints.

F. Complete installation of pipe and appurtenances as set forth in AWWA C600 and as specified.

3.5 Anchor tees, bends and plugged, valved or capped ends of pipe with concrete thrust blocks as necessary and as shown. Place blocks so that the pipe and fitting joints will be accessible for inspection and repair.

3.6 Water lines shall not be laid within nine feet of sanitary sewer lines. When this separation distance can not be achieved, the water and sewer lines shall be made to comply with 30 TAC Chapters 290 and 217. Contractor shall notify engineer upon discovery of minimum separation distance not being met.

3.7 Hydrostatic Testing: See Section 01400 for testing requirements

3.8 Do not enclose or cover any work until inspected.

END OF SECTION

SECTION 02669

VALVES AND COUPLINGS

PART 1 GENERAL

1.1 SECTION INCLUDES:

A. This section includes all material, labor and other items necessary to furnish, install, and test, all pipe, pipe supports, anchors, fittings, valves, specials as shown and specified, and the installation of in-line equipment and appurtenances furnished by others, for process piping systems, and plumbing piping systems.

1.2 RELATED SECTIONS

A. Section 01300 – Submittals.

B. Section 01400 – Quality Control.

C. Section 01600 – Materials and Handling.

D. Section 02665 – Water System.

1.3 SUBMITTALS:

A. Procedures for Submittals: Section 01300.

B. The Contractor shall submit shop drawings of all fabricated piping and shall submit shop drawings and/or manufacturer’s literature for all valves, gauges, and miscellaneous appurtenances, for review prior to ordering or installing any item.

C. Product Data: Manufacturer's product data sheets on all materials incorporated into work.

PART 2 PRODUCTS

2.1 COUPLINGS AND FITTINGS

A. Flanges, Gaskets and Bolts:

1. Cast iron flanges shall conform to ANSI B16.1 Class 125 or 250 as required on the Drawings.

2. Flange gaskets shall be full-face type, rubber, suitable for the intended service. Substitution of other gasket materials shall be only with the express written consent of the Engineer.

a. Thickness shall be 1/16" for pipe 10" and less and 1/8" for larger pipe.

b. Flange assembly bolts shall be standard square head carbon steel machine bolts with heavy, hot pressed, hexagon nuts, ANSI B18.2.

c. Threads shall conform to ANSI B1.1, coarse thread series, Class 2 fit. Bolt length shall be such that after joints are made up the bolt shall protrude through the nut, but not more than ½".

d. Bolts and nuts for use in submerged service shall be 314 stainless steel.

e. All screwed flanges on cast iron pipe shall be refaced, as required, after fabrication to ensure that pipe ends are flush with face of flange.

3. Forged steel flanges shall conform to ANSI B16.5, R.F.

a. Flange gaskets shall match raised faces and shall be asbestos composition.

b. On 3½" flanges and smaller, gaskets shall be $^{1}/_{16}$" thick.

c. On 4" flanges and larger, gaskets shall be $^{1}/_{8}$" thick.

d. Flange assembly bolts shall be standard square head carbon steel machine bolts with heavy, hot pressed hexagon nuts, ANSI B18.2.

e. 150 psi steel flanges may be bolted to cast iron valves, fittings or other parts, having either integral Class 125 cast iron flanges or screwed Class 125 companion flanges.

f. When such construction is used, the raised face on the steel flange shall be removed.

g. Where shown on the Drawings, steel flanges shall match the bolt pattern of ANSI B16.1 Class 250.

B. Pipe Threads:

1. Unless noted otherwise, all pipe threads shall conform in dimensions and limits of size to ANSI B2.1, taper joint thread.

C. Flange Coupling Adapters:

1. Flanged coupling adapters shall be Clow F-2535, Dresser Style 127 or 128, or equal.

2. Coupling gaskets shall be as recommended by the coupling manufacturer for the service intended.

D. Compression Fittings:

1. Compression fittings for copper pipe shall be Dresser Style 88, McDonald, or equal.

E. Joints:

1. All other joints shall be mechanical type or push-on type.

2. Lubricant for push-on type shall be that recommended by the manufacturer of the pipe.

F. Flexible Couplings:

1. There shall be installed where shown on the Plans and as required for proper pipe make-up, sleeve-type couplings equal to Style 253 couplings, as manufactured by the Dresser Manufacturing Division of Dresser Industries or approved equal.

2. They shall be designed to fit accurately, the outside diameters of the pipe to which they are to connect.

3. Gaskets shall be of molded rubber, Dresser Plain, Grade 27 or equal.

4. Couplings shall be furnished complete with bolts, nuts, and gaskets.

5. Middle rings shall be made up without a pipe stop where necessary for pipe installation or future removal of valves and fittings.

6. The ends of pipe and fittings which are to receive sleeve-type couplings shall be dressed for a distance of not less than the length of the middle ring plus the width of one follower ring in order to remove welding beads or any obstruction to free the movement of the middle ring.

7. There shall be harnesses provided on steel pipe where shown on the Plans, or as necessary for restraint.

8. The harnesses shall be designed for the design operating pressure of the pipeline with a safety factory of 2.

9. The harnesses are to be designed in accordance with AWWA Manual M11, Steel Pipe Design and Installation.

## 2.2 VALVES

A. General

1. Valves shall be as specified in the Piping Specification Sheets, or as specified herein. A union or flagged connection shall be provided within 2 feet of each threaded end valve unless the valve can be otherwise easily removed from the piping. Unless otherwise indicated, the direction of rotation of the valve operating wheel, wrench nut, or lever shall be to the left (counterclockwise) to open the valve.

2. All valves, except those, which are equipped with power/pneumatic operators, shall be provided with manual operators. Unless otherwise specified, each manual operator shall be equipped with an operating wheel.

3. Chain wheels and operating chains shall be provided on all valves 4" and larger with centerline more than 7'6" above the floor except where other operator types are specifically required. Each chain wheel operated valve shall be equipped with a chain guide which will permit rapid handling of the operating chain without "gagging" of the wheel and will also permit reasonable side pull on the chain. Operating chains shall be heavily plated with zinc or cadmium and shall be looped to extend to within 4 feet of the floor below the valve. Where recommended by the manufacturer, the operator shall be provided with a hammer blow wheel.

4. Wrench nuts shall be provided on all buried valves, on all valves which are to be operated through floor boxes, and where shown. All wrench nuts shall comply with Section 20 of AWWA C-500. Not less than two operating keys shall be provided for operation of the wrench nut operated valves.

5. For all valves buried at a depth of greater than 3 feet, an extension stem shall be provided to bring the operating nut within 2 feet of the finished elevation.

6. Bolt patterns for the flange connections shall match the pipe either Class 125 or Class 250 as shown on the plans.

B. Buried Valve Boxes & Extension Stems

1. Valves buried in the ground shall be provided with cast iron valve boxes of proper dimensions to fit over the valve bonnets and the extend to such elevation at or slightly above the finished ground line as directed by the Engineer.

2. Tops shall be complete with covers and shall be adjustable.

3. Valve boxes shall be set vertical and concentric with the valve stem.

4. Any valve box, which has so moved from its original position as to prevent the application of the valve key, shall be satisfactorily reset by the Contractor at his own expense.

5. A concrete pad 1.5’ x 1.5’ x 4” thick shall be poured around all valve boxes which are not to be located within proposed or existing pavements.

6. Extension stems shall be provided and installed for all valves with 2” square nut operators so that operating nut is within 2’ of the ground surface.

7. Valve boxes shall be the H-10346, 562-A, two-piece, sliding type, 5½" shaft, 24-36" extension, with drop cover marked water as manufactured by the Mueller Co. or Engineer approved equal.

8. Except as may be otherwise approved by the Engineer, all gate valves required for this Contract shall be from one manufacturer, and similar types and sizes shall be identical and the parts interchangeable.

C. Gate Valves

1. Gate valves, 2 inches through 12 inches shall be designed for a working pressure 200 psi.

2. Valves shall conform to AWWA C509 R/S “550 Coated Epoxy” with iron bonnet (bronze mounted), non-rising stem resilient seat, two O-ring stem seals and 2" x 2" square operating nut.

3. Valves shall open when the operating nut is turned to the left (counterclockwise).

4. Unless otherwise specified, valves 14 inches in diameter and larger shall be designed for horizontal installation with totally enclosed gear cases.

5. Valve ends shall be mechanical joint complete with accessories or as specified.

6. Tapping valves shall conform to above specification except that the connections shall be ANSI B16.1, Class 125 flange on one side (inlet) and mechanical joint on the other (outlet) or as specified.

7. Wedge shall be constructed of ductile iron, fully encapsulated in synthetic rubber except for guide and wedge nut areas.

8. Wedge rubber shall be molded in place and bonded to the ductile iron portion, and shall not be mechanically attached with screws, rivets, or similar fasteners.

9. Valve operator shall be capable of seating and unseating valves and operating through their full stroke against pressures and velocities as shown by conditions on the Plans.

10. Manual operators shall be the worm gear type having permanently grease lubricated totally enclosed gearing with operating nut and gear ratio design to require not more than 40 lbs. pull. Operator shall be provided with adjustable limit stops on the input shaft to the operator. Limit stops on output shaft of operator will not be permitted. Operator shall be designed for direct burial service and valve box shall be provided over operating nut. Extension stem shall be provided to bring operating nut within 2 feet of ground surface.

11. The hand wheel operator for gate valves shall have the minimum diameter:

| Valve Size (in.) | Hand Wheel Operator Dia. (in) |
|---|---|
| 3 | 7 |
| 4 | 10 |
| 6 | 12 |
| 8 | 14 |
| 10 | 16 |
| 12 | 16 |
| Greater than 12” | consult manufacturer |

12. Resilient Seated Gate Valve (RSGV) shall be ductile iron body, heat-fusion nylon or fusion bonded epoxy coated, non-rising stem, flanged or mechanical jointed, and shall conform to AWWA C504.

13. Pre-approved Acceptable Manufacturers

    a. Mueller

    b. American flow control / American Darling

    c. M & H

    d. American AVK

    e. Clow

    f. EJIW

    g. J&S

    h. Kennedy

D. Plug Valves:

1. Valves shall be of the non-lubricated, eccentric type with resilient face plugs with flagged ends for pump stations and mechanical joint for buried service.

2. Port areas of valves shall be at least 80% of full pipe area. Bodies shall be semi-steel with seats.

3. Seats in 3" and larger valves shall be pure nickel or stainless steel on all surfaces contacting the plug face.

4. Valves shall have permanently lubricated, stainless steel bearings in the upper and lower plug stem journals.

5. All valves shall be of the bolted bonnet design.

6. All 4" and larger valves shall be deigned so that they can be repacked without removing the bonnet and the packing shall be adjustable.

7. Flanged valves shall be faced and drilled to ANSI 125/150 lb. standard.

8. Flanges of valves through 12" shall have face-to-face dimensions of standard gate valves.

9. Resilient plug facings shall be of neoprene suitable for use with sanitary sewage.

10. Valves shall have lever or gear actuators and tee wrenches, extension stems, etc., as required for either submerged or exposed service.

11. All valves 6" and larger shall be equipped with gear actuators.

12. All gearing shall be enclosed in semi-steel housing and be suitable for running in a lubricant with seals provided on all shafts to prevent entry of dirt and water into the actuator.

13. The actuator shaft and the quadrant shall be supported on permanently lubricated bronze bearings.

14. Actuators shall clearly indicate valve position and an adjustable stop shall be provided to set closing torque.

15. Valves and gear actuators for buried or submerged service shall have seals on all shafts and gaskets on the valve and actuator covers to prevent the entry of water.

16. Actuator mounting brackets for buried or submerged service shall be totally enclosed and shall have gasket seals.

17. All exposed nuts, bolts, springs, and washers shall be stainless steel.

18. Plug Valves shall be Series 100 plug valves by DeZurik, or equal.

E. Slanting Disc Check Valves

1. Check valves shall be furnished and installed at locations shown on the Plans.

2. Valves shall be iron body, bronze mounted, swing check valves with outside weight and lever and designed for 150 lbs. working pressure.

3. Flanged valves shall be faced and drilled to ANSI 125/150 lb. standard.

4. All exposed nuts, bolts, springs, and washers shall be stainless steel.

5. Valves shall include adjustable packing and grease fittings.

6. Valves shall be 114 Horizontal Swing Check Valves as manufactured by CLOW Corp., Swing Check Valves by Mueller Corp., Style 159-02 by Dresser, or equal.

F. Pipe Supports

1. Install adjustable pipe supports manufactured by Anvil International Inc. or Engineer approved equal as shown on the plans.

G. Joint Restraint

1. Where thrust rod anchors are shown or specified the Star Joint Restraint System as manufactured by Star National Products of Columbus, Ohio shall be utilized.

2. This system consists of the use of Super Star Tiebolts, Tienuts, Tierods (¾") and Tiecouplings.

3. The number of tie rods required is listed as follows:

| Pipe Size (in.) | Number of ¾" Rods Required |
|---|---|
| 6 | 2 |
| 8 | 2 |
| 10 | 2 |
| 12 | 4 |
| 14 | 4 |
| 16 | 6 |
| 18 | 6 |
| 20 | 8 |
| 24 | 10 |
| 30 | 12 |

END OF SECTION

SECTION 02675

DISINFECTION OF WATER DISTRIBUTION SYSTEM

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Disinfection of potable water distribution and transmission system.

B. Testing and reporting results.

1.2 RELATED SECTIONS

A. Section 02665 – Water Systems

1.3 REFERENCES

A. AWWA B300 - Standard for Hypochlorites.

B. AWWA C651 - Standards for Disinfecting Water Mains.

1.4 SUBMITTALS FOR INFORMATION

A. Section 01300 - Submittals: Procedures for submittals.

B. Test Reports: Submit all test reports and indicate results comparative to specified requirements.

C. Certificate: Certify that cleanliness of water distribution system meets or exceeds Texas Department of Health requirements.

1.5 PROJECT RECORD DOCUMENTS

A. Submit under provisions of Section 01700.

B. Disinfection report:

1. Type and form of disinfectant used.

2. Date and time of disinfectant injection start and time of completion.

3. Test locations.

4. Initial and 24 hour disinfectant residuals (quantity in treated water) in ppm for each outlet tested.

5. Date and time of flushing start and completion.

6. Disinfectant residual after flushing in ppm for each outlet tested.

C. Bacteriological report:

1. Date issued, project name, and testing laboratory name, address, and telephone number.

2. Time and date of water sample collection.

3. Name of person collecting samples.

4. Test locations.

5. Initial and 24 hour disinfectant residuals in ppm for each outlet tested.

6. Coliform bacteria test results for each outlet tested.

7. Certification that water conforms, or fails to conform, to bacterial standards of Texas Department of Health.

1.6 QUALITY ASSURANCE

A. Perform Work in accordance with AWWA C651.

B. Water Treatment Firm: Company specializing in disinfecting potable water systems specified in this Section with minimum three (3) years documented experience.

C. Testing Firm: Company specializing in testing potable water systems, certified by the State of Texas.

D. Submit bacteriologist's signature and authority associated with testing.

1.7 REGULATORY REQUIREMENTS

A. Conform to requirements of AWWA C651 for performing the work of this Section.

B. Provide certificate of compliance from Texas Department of Health indicating approval of water system.

PART 2 PRODUCTS

2.1 DISINFECTION CHEMICALS

A. Chemicals: AWWA B300, Hypochlorite.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that piping system has been cleaned, inspected, and pressure tested.

B. Perform scheduling and disinfecting activity with start-up, testing, adjusting and balancing, demonstration procedures, including coordination with related systems.

3.2 EXECUTION

A. Provide and attach required equipment to perform the work of this Section.

B. Introduce treatment into piping system.

C. Maintain disinfectant in system for 24 hours.

D. Flush, circulate, and clean until required cleanliness is achieved; use municipal domestic water.

E. Replace permanent system devices removed for disinfection.

F. Pressure test system to 150 psi. Repair leaks and re-test.

3.3 FIELD QUALITY CONTROL

A. Section 01400 - Quality Assurance: Field inspection and testing.

B. Test samples in accordance with AWWA C651.

END OF SECTION

SECTION 02731

SANITARY SEWER SYSTEMS

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Sanitary sewer lines including, blocking, joints, fittings, and other appurtenances for sewer lines

1.2 REFERENCES

A. ANSI/AWWA C104/A21.4-08 - Cement Mortar Lining for Ductile Iron Pipe and Fittings

B. ANSI/AWWA C110/A21.10-12 - Ductile Iron and Gray Iron Fittings

C. ANSI/AWWA C111/A21.11-12 - Rubber Gasket Joints for Ductile-Iron Pressure Pipe and Fittings

D. ANSI/AWWA C150/A21.50-08 - Thickness Design of Ductile-Iron Pipe.

E. ANSI/AWWA C151/A21.51-09 - Ductile Iron Pipe, Centrifugally Cast

F. ANSI/AWWA C153/A21.53-11 - Ductile Iron Compact Fittings

G. ASTM A746 - Ductile Iron Gravity Sewer Pipe.

H. ASTM D-3034 – Pipe Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings

I. ASTM D-3212 – Joints for Drain and Sewer Plastic Pipes Using Elastomeric Seals

J. ASTM F-477 – Elastomeric Seals (Gaskets) for Joining Plastic Pipe

K. ASTM D-1784 – Rigid Poly (Vinyl Chloride) (PVC) Compounds and chlorinated Poly(Vinyl Chloride) (CPVC) Compounds

L. ASTM D-2412 – Standard Test Method for Determination of External Loading of Plastic Pipe by Parallel Plate Loading

M. ASTM D-2321 – Underground Installation of Thermoplastic Pipe for Sewer and Other Gravity-Flow Applications

1.3 SUBMITTALS

A. Section 01300 - Procedures for Submittals.

B. Product Data: Manufacturer's product data sheets on all materials incorporated into work.

C. Quality Control Submittals: For information only.

1. Certificates: Manufacturer's certificates attesting compliance with applicable specifications for grades, types, classes, and other properties.

D. Contract Closeout Submittals: Refer to Section 01700.

1. Project Record Documents: Submit documentation according to Section 01700. Accurately record installed locations of piping, and service connections, and accessories.

1.4 QUALITY ASSURANCE

A. Pipeline installation shall be in accordance with manufacturer's recommendations.

B. Pipe shall be kept clean of all foreign matter.

1. At termination of pipe laying, provide suitable cover to close open end until burying operations are resumed.

1.5 DELIVERY, STORAGE AND HANDLING

A. Each load of pipe delivered to the job site shall be inspected by the Resident Project Representative.

B. Pipe shall be transported with ends covered to prevent debris accumulation during transport

C. Purchasing, handling, and shipping shall be completed on accordance with the manufacturer’s instructions.

1.6 PRODUCT CONDITIONS

A. Perform no pipe work in fill areas until embankment or fill has been completed to at least two (2) feet above top of pipe and properly compacted.

PART 2 PRODUCTS

2.1 GRAVITY SYSTEMS

A. Pipe:

1. Polyvinyl Chloride Pipe (PVC)

a. PVC pipe shall be in accordance with ASTM D-3034 with integral wall ball and spigot joints.

b. PVC pipe shall be manufactured from clean, virgin, NSF approved PVC compound meeting the requirements of Cell Class 12454-B as defined by ASTM D-1784.

c. Pipes shall be produced with a wall thickness corresponding to dimension ratio SDR-35 or SDR-26, with a pipe stiffness valve of 115 psi when tested in accordance with ASTM D-2412.

d. Green pipe shall be supplied.

e. Pre-approved acceptable manufacturers:

1) North American Specialty Products

2) JM/PW Eagle

3) Diamond Plastics

4) Jet Stream

5) Northern

6) Royal

2. Restrained Joint PVC Pipe

a. Pipe shall be SDR 26 unless otherwise indicated on the Plans.

b. The restrained joint pipe system shall meet all requirements of ASTM D2241.

c. Pipe and coupling shall be made from unplasticized PVC compounds having a minimum cell classification of 12454-B as defined in ASTM D1784.

d. The compound shall qualify for a Hydrostatic Design Base of 4,000 psi of water at 73.4° F in accordance with the requirements of ASTM D2837.

e. Green pipe shall be supplied.

f. Restrained joint PVC pipe products shall have been tested and approved by an independent third-party laboratory for continuous use at rated pressures. Copies of agency approval reports or product listing shall be provided to the Engineer if requested.

g. Pipe shall be joined using non-metallic couplings which, together, have been designed as an integral system for maximum reliability and interchangeability.

1. High-strength flexible thermoplastic splines shall be inserted into mating precision-machined grooves in the pipe and coupling to provide full 360° restraint with evenly distributed loading.

2. Integral bell joints shall incorporate an elastomeric sealing gasket meeting the requirement of ASTM F477.

3. Joints shall be designed to meet the leakage test requirements of ASTM D3139.

h. Pre-approved Manufacturer for Restrained Joint PVC Pipe

1) North American Specialty Products – Certa-Flo Greenline

2) Diamond Plastics

3) Jet Streem

4) JM Eagle

5) Northern

3. High Density Polyethylene Pipe (HDPE)

a. Polyethylene pipe shall be made from high-density polyethylene resin compound that meets ASTM D1248. Dimensions and workmanship shall conform to ASTM F714.

b. The polyethylene pipe shall be SDR-19 unless otherwise indicated on the plans.

c. Piping shall be extruded from a polyethylene compound and shall conform to the following requirements.

1. The polyethylene resin shall meet or exceed the requirements of ASTM D3350 for PE 3408 material with a cell classification of 335434C or better.

2. The polyethylene compound shall be suitably protected against degradation by ultraviolet light by means of carbon black, well dispersed by pre-compounding in a concentration of not less than 2 percent.

3. All pipe shall be made of virgin material. No rework except that obtained from the manufacturer's own production of the same formulation shall be used.

4. The pipe shall be homogenous throughout and shall be free of visible cracks, holes, foreign material, blisters, or other deleterious faults.

d. All polyethylene pipe used shall be of the same type, grade, and class of polyethylene compound and shall be the product of one manufacturer.

e. Sanitary sewer pipe exterior shall be green in color or contain green striping. Sanitary sewer pipe interior shall be light in color for external video inspection.

B. Joints:

1. Joints shall be mechanical joint or push-on joint conforming to AWWA C111.

a. Joint material for Ductile Iron Pipe shall be rubber gasket type conforming to ANSI/AWWA C111/A21.11.

b. The gaskets shall be furnished by the pipe manufacturer.

2. Each mechanical joint shall consist of a bell cast integrally with the pipe or fitting and provided with an exterior flange having bolt holes and a socket with annular recesses for the sealing gasket and the plain end of the pipe or fitting; a pipe or plain end; a sealing gasket; a follower gland with bolt holes; and tee-head bolts and hexagonal nuts. The mechanical joint shall meet the requirements of ANSI/AWWA C111/A21.11-85.

3. Push-on (bell and spigot) joints shall consist of a bell cast integrally with the pipe or fitting and a socket with annular recesses for the sealing gasket and the plain end of the pipe or fitting.

a. The push-on joints shall meet the requirements of ANSI/AWWA C111/A21.11-85.

b. Joints for PVC pipe shall conform to ASTM D-3212 with elastomeric seals conforming to ASTM F-477.

4. All piping shall be push-on as shown on the drawings, unless otherwise specified.

C. Fittings:

1. Standard Fittings: All bends, tees, plugs, adapters, wyes, and other fittings shall meet the requirements of the type and kind of pipe used.

2. Adapters:

a. When joining dissimilar pipe materials or repairing pipe, suitable adapters shall be used.

b. The adapters shall be insert or bonded coupling type and shall meet strength and chemical requirements of ASTM C594.

3. Ductile Iron:

a. Fittings shall be push-on type meeting ANSI/AWWA C110/A21.10.

b. Fittings shall be cement lined in accordance with ANSI/AWWA C104/A21.4 and shall have a bituminous coated exterior per ANSI/AWWA C110/A21.10 or C153/A21.53.

D. Sewer Service Connections

1. Sewer service connections shall tie-in to sewer line with a wye. Wyes shall meet the same requirements of the pipe material used.

2. Sewer service connections for sewer lines install by pipe bursting shall be made using a Fatboy sewer tap manufactured by Inserta-Tee or Engineer approved equal.

2.2 ACCESSORIES

A. Non-shrink grout:

1. Gifford-Hill - Supreme.

2. L&M – Crystex.

3. Master Builders – Masterflow 713 Grout.

4. Sauereisen Cements – F0100 Level Fill Grout.

5. Others as approved by the Engineer.

B. Waterstops:

1. Waterstops shall be as recommended by pipe manufacturer and approved by the Engineer.

C. Polyethylene Encasement:

1. When ductile iron pipe is installed, the entire length of the D.I.P. with the exception of bore encasement shall be encased with polyethylene.

2. D.I.P. shall be encased with 8-mil thick polyethylene in accordance with ANSI/AWWA C104/A21.5 standard.

PART 3 EXECUTION

3.1 PREPARATION

A. Stake locations of fittings, valves and accessories prior to installation for review by Engineer.

B. Prior to installation, remove foreign matter from within pipes and fittings and verify material is in satisfactory condition.

C. Trench sufficiently ahead of pipe installation to uncover any potential conflicts with grade.

D. Each joint shall be carefully inspected before being placed in the trench. Any joint found to be cracked or otherwise damaged as to impair its usefulness shall be plainly marked then removed from the site as soon as possible.

3.2 PIPE INSTALLATION

A. Pipe shall be installed in accordance with ASTM D2321/ASTM D2231.

B. Preparation:

1. Do not lay pipe in water, or when trench or weather are unsuitable for work.

a. Keep water out of trench until jointing is complete and bedding is placed to top of pipe.

b. When work is not in progress, close ends of pipe and fittings securely so that no trench water, earth or other substances will enter pipes or fittings.

2. Keep inside of pipe free from foreign matter during operations by plugging or other approved method.

3. Place pipe so that full length of each section rests solidly upon pipe bed, with recesses excavated to accommodate bells and joints. Take up and relay pipe when grade or joint is disturbed after laying.

4. Handle pipe and accessories so that pipe placed in trench is sound and undamaged. Take particular care not to injure pipe coating when applicable.

5. Cut neatly, using approved type mechanical cutter without damaging pipe. Use wheel cutters when practicable.

C. Excavation, Compaction and Backfill: In accordance with Section 02225, Excavating, Backfilling and Compacting for Utilities.

D. Bedding: In accordance with Section 02225 and as shown on the Drawings.

E. Placing and Laying:

1. Set and bury lines accurately to grades as shown on the plans.

2. Do not exceed 75 percent of pipe manufacturer's recommendations for deflections from straight line or grade as required by vertical curves, horizontal curves, or offsets. If alignment requires deflections in excess of these limitations, use fittings.

3. Intersecting lines shall be joined by an appropriate fitting.

4. Any adjustment to obtain correct line shall be made by tamping or removing soil and in no case by wedging or blocking pipe.

5. Pipe shall be secured against upheaval or floating during the placement of concrete bedding, encasement, or anchors.

F. Joints:

1. Make push-on joints in accordance with manufacturer's recommendations. Lay spigot ends downstream and push-on to full depth.

2. Spigot and bells shall be cleaned thoroughly before the application of lubricant and attachment of the preformed joint gasket.

G. Connections to Existing Sewers:

1. Connections to existing sewers shall not be made until all of the proposed sewer lines and manholes have been constructed, cleaned and approval granted by the Engineer for making connection.

2. No connection shall be made until all new sewers have passed specified leakage tests.

H. HDPE Pipe

1. The polyethylene pipe shall be assembled into one continuous length at the site using the thermal butt-fusion method in accordance with the manufacturer's recommendations to provide a leak proof joint. The resultant joint shall be as strong as the intervening lengths. Threaded or solvent-cement joints and connections are not permitted. All equipment and procedures used shall be used in strict compliance with the manufacturer's recommendations. Fusing shall be accomplished by personnel certified as fusion technicians by a manufacturer of polyethylene pipe and/or fusing equipment.

2. The butt-fused joint shall truly align the two sections of pipe and shall have uniform roll-back beads resulting from the use of proper temperature and pressure. The joint surfaces shall be smooth. The fused joint shall be watertight and shall have tensile strength equal to that of the pipe. All joints shall be subject to acceptance by the Engineer prior to insertion. All defective joints shall be cut out and replaced at no cost to the City. Any section of the pipe with a gash, blister, abrasion, nick, scar, or other deleterious fault greater in depth than ten percent (10%) of the wall thickness, shall not be used and must be removed from the site. However, a defective area of the pipe may be cut out and the remaining pieces fused in accordance with the procedures stated above. In addition, any section of pipe having other defects such as concentrated ridges, discoloration, excessive spot roughness, pitting, variable wall thickness or any other defect of manufacturing or handling as determined by the Engineer shall be discarded and not used.

3. The handling of the joined pipeline shall be in such a manner that the pipe is not damaged by dragging it over sharp and cutting objects. Ropes, fabric, or rubber-protected slings and straps shall be used when handling pipes. Chains, cables, or hooks inserted into the pipe ends shall not be used. Two slings spread apart shall be used for lifting each length of pipe. Pipe or fittings shall not be dropped onto rocky or unprepared ground. Slings for handling the pipeline shall not be positioned at butt-fused joints. Polyethylene pipe shall not be crimped in any way during construction.

## 3.3 REMOVAL AND REPLACEMENT OF PIPE IN ORIGINAL LOCATION

A. Preparation

1. Carefully remove or protect surface features in work area. Excavate to completely expose the existing pipe, taking adequate precautions not be disturb any other existing underground facilities and handling excavated materials as described in other Sections.

2. The section of pipe to be replaced shall be isolated by plugging and/or by-pass pumping or by any other method proposed by the Contractor and approved by the Engineer. All plugging and by pass pumping shall be considered subsidiary to the cost of removal and replacement of pipe unless otherwise specified.

B. Excavation

1. Remove and dispose of the existing pipe and concrete encasement, if any. This shall be phased and coordinated with its replacement so as to minimize public inconvenience.

2. The trench bottom shall be reshaped to accommodate the new pipe and embedment or encasement as required.

C. Bedding: In accordance with Section 02225 and as shown on the drawings.

D. Placing and Laying

1. In accordance with Section 3.2 E above.

2. Make connections to existing or proposed manholes or cleanouts and to existing pipe remaining in place.

3. Install wyes or tees, with branches temporarily plugged, to make reconnections to existing service laterals, if any.

4. Except for testing, service shall be maintained at all times. Where necessary, services shall be temporarily reconnected to the new main.

## 3.4 TESTING AND INSPECTION

A. Low Pressure Air Test:

1. A low pressure air test shall be performed after completing a section of sewer line in accordance with the following:

   a. The procedure for the low pressure air test shall conform to the procedures described in ASTM C-828, ASTM C-924, ASTM F-1417 or other appropriate procedures, except for testing times.

   b. The test times shall be as outlined below.

   c. For sections of pipe less than 36-inch average inside diameter, the following procedure shall apply unless the pipe is to be joint tested.

   d. The pipe shall be pressurized to 3.5 psi greater than the pressure exerted by groundwater above the pipe.

   e. Once the pressure is stabilized, the minimum time allowable for the pressure to drop from 3.5 pounds per square inch gauge to 2.5 pounds per square inch gauge shall be computed from the following equation:

$$T \equiv \frac{0.085 \times D \times K}{Q}$$

T = time for pressure to drop 1.0 pound per square inch gauge in seconds
K = 0.000419 x D x L, but not less than 1.0
D = average inside pipe diameter in inches
L = length of line of same pipe size being tested, in feet
Q = rate of loss, 0.0015 cubic feet per minute per square foot internal surface

   f. Since a K value of less than 1.0 shall not be used, there are minimum testing times for each pipe diameter as follows:

| Pipe Diameter (inches) | Minimum Time (seconds) | Maximum Length for Minimum Time (feet) | Time for Longer Length (seconds/foot) |
|---|---|---|---|
| 6 | 340 | 398 | 0.855 |
| 8 | 454 | 298 | 1.520 |
| 10 | 567 | 239 | 2.374 |
| 12 | 680 | 199 | 3.419 |
| 15 | 850 | 159 | 5.342 |
| 18 | 1020 | 133 | 7.693 |
| 21 | 1190 | 114 | 10.471 |
| 24 | 1360 | 100 | 13.676 |

| | | | |
|---|---|---|---|
| 27 | 1530 | 88 | 17.309 |
| 30 | 1700 | 80 | 21.369 |
| 33 | 1870 | 72 | 25.856 |

g. The test may be stopped if no pressure loss has occurred during the first 25% of the calculated testing time.

h. If any pressure loss or leakage has occurred during the first 25% of the testing period, then the test shall continue for the entire test duration as outlined above or until failure.

B. Infiltration and Exfiltration Test:

1. Infiltration and Exfiltration tests shall conform to 30 TAC 217.57(a)(2) and shall be performed under the observation of the Owner and Engineer.

2. If an Infiltration or Exfiltration Test produces results that exceed the maximum allowable limit as stated in 30 TAC 217.57 (a)(2) and as outlined below, the Contractor shall repair or replace all necessary sections of the sewer line to bring the line into compliance with such standards.

3. The total infiltration shall not exceed 50 gallons per inch diameter per mile of pipe per 24 hours at a minimum test head of 2.0 feet above the crown of the pipe at the upstream manhole or two feet above the existing ground water whichever is greater.

4. When pipes are installed below the groundwater level, an infiltration test shall be used in lieu of an Exfiltration test.

5. For pipe constructed within the 25-year flood plain, the Infiltration or Exfiltration shall not exceed 10 gallons per inch diameter per mile of pipe per 24 hours at a minimum test head of 2.0 feet.

6. If the Exfiltration exceeds the maximum allowable amount, the Contractor shall replace or repair the section of the sewer line necessary to meet the specified limits.

C. Deflection Test:

1. A Deflection Test shall be performed on all flexible pipes (PVC).

2. The deflection test shall conform to the requirements of 30 TAC 217.57(b) as outlined below.

3. For collection pipes with an inside diameter less than 27 inches, deflection measurement requires a Rigid Mandrel. Flexible mandrels shall be prohibited.

a. The Rigid Mandrel shall have an outside diameter equal to 95% of the average inside diameter of the pipe.

b. The Rigid Mandrel shall be constructed of metal or a rigid plastic material and shall be able to withstand 200 psi without being deformed and shall have a length of at least 75% of the inside diameter of the pipe.

c. The Mandrel shall have 9 or more odd number of runners.

d. Each Mandrel shall use a separate proving ring.

e. The Mandrel shall have 9 or more odd number of runners.

4. Television Inspection shall not substitute for a Deflection Test.

5. Mechanical pulling devices shall not be used during Testing.

6. Deflection Tests shall be performed no sooner than 30 days following final placement of backfill.

7. If the deflection exceeds the maximum allowable amount (5%), the Contractor shall replace or repair the section of the sewer line necessary to meet the specified limits.

D. Upon completion of all required testing, the contractor shall provided a signed and notarized affidavit certifying that the system has been tested and meets applicable requirements.

E. System Flushing:

1. Upon completion of each sewer line or segment of line the contractor shall flush the sewer line with a sufficient quantity of clean water. The flushing shall be performed until the water runs clear and clean.

2. The quantity of water shall be sufficient to properly flush the line and shall not be less than 200 gallons per minute. The contractor shall be responsible for acquiring the necessary water and facilities for flushing.

F. Final Inspection:

1. Prior to final inspection, the Contractor shall complete all work on the portion of the line to be tested. The ditches shall be dressed and debris removed.

2. The final inspection shall include the entire length of the line and include clean up.

3. All defects noted shall be repaired by Contractor at his own expense, prior to final payment.

END OF SECTION

SECTION 02923

LANDSCAPE GRADING

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Final grade topsoil for finish landscaping.

1.2 RELATED SECTIONS

A. Section 01400 - Quality Control

B. Section 01410 - Testing Laboratory Services: Testing fill compaction.

C. Section 02205 - Soil Materials.

D. Section 02224 - Excavation, Backfilling and Compacting for Structures

E. Section 02225 - Excavation, Backfilling and Compacting for Utilities

F. Section 02936 – Seeding

PART 2 PRODUCTS

2.1 MATERIAL

A. Topsoil: Fill Type S4 as specified in Section 02205.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify building and trench backfilling have been inspected.

B. Verify substrate base has been contoured and compacted.

3.2 SUBSTRATE PREPARATION

A. Eliminate uneven areas and low spots.

B. Remove debris, roots, branches, stones, in excess of 1 inch in size. Remove subsoil contaminated with petroleum products.

C. Remove existing soil to a depth of 10 inches below the existing surface in areas where topsoil is scheduled to accommodate the proposed topsoil and mulch. Scarify in areas where equipment used for hauling and spreading topsoil has compacted subsoil.

3.3 PLACING TOPSOIL

A. Place topsoil in areas where seeding, sodding, and planting is required, to thickness as scheduled. Place topsoil during dry weather.

B. Fine grade topsoil to eliminate rough or low areas. Maintain profiles and contour of subgrade.

C. Remove roots, weeds, rocks, and foreign material while spreading.

D. Manually spread topsoil close to plant life, buildings, and structures to prevent damage.

E. Lightly compact placed topsoil.

F. Remove surplus subsoil and topsoil from site.

G. Leave stockpile area and site clean and raked, ready to receive landscaping.

3.4 TOLERANCES

A. Top of Topsoil: Plus or minus ½ inch.

3.5 PROTECTION

A. Protect landscaping and other features remaining as final work.

B. Protect existing structures, fences, utilities, paving, and curbs.

END OF SECTION

SECTION 02936

SEEDING

PART 1 GENERAL

1.1 SECTION INCLUDES

A. Preparation of subsoil.

B. Placing topsoil.

C. Temporary Cool Weather Seed Mixture (For Installation if Requested By Engineer).

D. Seeding, Hydroseeding, mulching, and fertilizer.

E. Maintenance.

1.2 RELATED SECTIONS

A. Section 02205 - Soil Materials: Topsoil material.

B. Section 02923 - Landscape Grading: Preparation of subsoil and placement of topsoil in preparation for the work of this Section.

1.3 REFERENCES

A. FS O-F-241 - Fertilizers, Mixed, Commercial.

B. Texas Seed Law.

1.4 DEFINITIONS

A. Weeds: Include Dandelion, Jimsonweed, Quackgrass, Horsetail, Morning Glory, Rush Grass, Mustard, Lambsquarter, Chickweed, Cress, Crabgrass, Canadian Thistle, Nutgrass, Poison Oak, Blackberry, Tansy Ragwort, Bermuda Grass, Johnson Grass, Poison Ivy, Nut Sedge, Nimble Will, Bindweed, Bent Grass, Wild Garlic, Perennial Sorrel, and Brome Grass.

1.5 MAINTENANCE DATA

A. Submit under provisions of Section 01700.

B. Maintenance Data: Include maintenance instructions, cutting method and maximum grass height; types, application frequency, and recommended coverage of fertilizer.

1.6 QUALITY ASSURANCE

A. Provide seed mixture in containers showing percentage of seed mix, year of production, net weight, date of packaging, and location of packaging.

B. All seed shall be labeled in accordance with the current rules and regulations of the Texas Seed Law and shall be free of noxious weeds as listed by the Board.

C. All legumes must be inoculated with an approved culture as per the manufacturer's recommendations.

1.7 REGULATORY REQUIREMENTS

A. Comply with all regulatory agencies for fertilizer and herbicide composition.

1.8 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, protect and handle products to site under provisions of Section 01600.

B. Deliver grass seed mixture in sealed containers unless otherwise authorized by the Engineer in writing. Seed in damaged packaging is not acceptable.

C. Seed, which has become wet, moldy, or otherwise damaged in transit or storage will not be acceptable.

D. Deliver fertilized in waterproof bags showing weight, chemical analysis, and name of manufacturer.

1.9 COORDINATION

A. Coordinate work under provisions of Section 01039.

1.10 MAINTENANCE SERVICE

A. Furnish maintenance of seeded areas for one year from Date of Substantial Completion.

PART 2 PRODUCTS

2.1 SEED MIXTURE

A. Normal Application Seed Mixture (For Installation Between 5:1 and 6:1 inclusive, unless otherwise approved by the Engineer)

| Seed | Minimum Seed Purity (Percent) | Minimum Germination (Percent) | Rate of Application (lb./acre) |
|---|---|---|---|
| Common Bermuda, hulled | 95.0% | 85.0% | 90 |

B. Flower Seed Mixture

| Seed | Minimum Seed Purity (Percent) | Minimum Germination (Percent) | Rate of Application (lb./acre) |
|---|---|---|---|
| Common Bermuda, hulled | 95.0% | 85.0% | 20 |
| Elbon rye | 95.0% | 85.0% | 20 |
| Crimson Clover | 95.0% | 85.0% | 18 |

C. Temporary Cool Weather Seeding

| Seed | Minimum Seed Purity (Percent) | Minimum Germination (Percent) | Rate of Application (lb./acre) |
|---|---|---|---|
| Elbon rye | 95.0% | 85.0% | 60 |
| Kentucky 31 Fescue | 95.0% | 85.0% | 20 |

1. If required, temporary seeding shall be installed using a drill seeder without fertilizer.

2. If temporary seeding is required, the contractor will be required to disc and drag the topsoil to remove the temporary vegetation prior to the installation of the normal seed mixture.

3. The price for disking, dragging, and removing the temporary vegetation shall be subsidiary to seeding bid Item.

D. Hydromulch, Seed, Lime, and Fertilizer (Slopes 0% to 5%)

1. All disturbed areas, apply the normal seed mixture using a hydroseeder along with the following components:

   a. Seed, as noted above for normal seed mixture.

   b. Fertilizer, as described below

   c. Liquid Lime, as described below

   d. Enviro-Tak fiber mulch binder, as distributed by Southwest Environment Services, Inc. (Tyler, Texas) at a rate of 60 lbs. Per acre.

   e. Fiber mulch at a rate of 2,000 lbs. Per acre.

2. The contractor shall install a micronutrient such as Turfblend, or equal, at the rate suggested by the supplier.

3. In addition to slopes between 0% and 5%, this mixture shall be applied to all areas receiving erosion control matting.

E. Bonded Fiber Matrix Much, Seed, Lime, and Fertilizer (Slopes >5%)

1. All disturbed areas shown on the plans, apply the normal seed mixture using a hydroseeder along with the following components:

a. Seed, as noted above for normal seed mixture.

b. Fertilizer, as described below.

c. Liquid Lime, as described below.

d. Bonded Fiber Matrix, as described below.

2. The Contractor shall install a micronutrient such as Turfblend, or equal, at the rate suggested by the supplier.

F. Creeping Red Fescue or perennial rye: 50 percent.

2.2 SOIL MATERIALS

A. Topsoil: As specified in Section 02205.

2.3 ACCESSORIES

A. Liquid Lime:

1. Liming will be required for all area when the normal seed mixture is applied.

2. The lime to be used shall be liquid lime and shall be applied at a rate of 5 gallons per acre.

3. The liquid lime shall be flowable dolomitic limestone ground to a fineness whereby 100% will pass through a 300-mesh screen.

4. The liquid lime shall be as distributed by Southwest Environment Services, Inc. of Tyler, Texas or approved equal.

5. The liquid lime shall be applied at the same time as the seed and fertilizer with the use of a hydroseeder.

B. Mulching Material: Oat or wheat straw, free from weeds, foreign matter detrimental to plant life, and dry. Hay or chopped cornstalks are acceptable.

C. Bonded Fiber Matrix Mulch:

1. Bonded Fiber Matrix Mulch shall be one of the following products or Engineer approved equals.

a. Flex Term by Profile.

b. Spoil Guard by Mat Inc.

c. Sparmatt by Central Fiber

d. SC-150 by North American Green.

D. Plaster/cellulose Fiber Mulch:

1. Plaster/cellulose fiber mulch shall be a mixture of plaster and natural cellulose fiber mulch.

2. The plaster shall consist of naturally-occurring high purity processed gypsum and necessary additives, such as retarders and accelerators and water to form a cemetitious binder that will produce a protective crust-like barrier within 4 to 8 hours after application.

3. The gypsum shall be produced from a quarried or mined source.

4. In addition, the gypsum shall be processed to be composed of a crushed, dry calcium sulfate hemihydrate (CA SO4.1/2 H20) having a purity of not less than 88%.

5. The processed gypsum plus the necessary additives shall be furnished in bags or bulk and be accompanied by bills of landing and shipping invoices stating the gypsum purity content, dry weight, and source of manufacture.

6. Processed gypsum, which has become partially air set, lumpy, or caked prior to use will be rejected.

7. The cellulose fiber mulch shall be produced from grinding clean, whole wood chips, or fiber produced from ground newsprint with a labeled ash content not to exceed 7%.

E. Fertilizer:

1. FS O-F-241, Type I, Grade A; recommended for grass, with fifty percent of the elements derived from organic sources; of proportion necessary to eliminate any deficiencies of topsoil to the following proportions:

2. The contractor shall have a turf analysis performed for the topsoil (4 maximum).

3. Based upon the results of the turf analysis, the following fertilizer requirement may be adjusted to suit the existing topsoil.

a. Fertilizer shall be thirty percent (30%) nitrogen, thirty percent (30%) phosphorous, and thirty percent (30%) potash commercial fertilizer and shall be spread at the minimum rate of 650 lbs. per acre.

b. In addition, trace elements such a K-Mag may be required if the need is shown by the turn analysis.

F. Water:

1. Clean, fresh and free of substances or matter, which could inhibit vigorous growth of grass.

2. The Contractor shall water the seed and fertilizer as he deems necessary to establish the grass, at no expense to the Owner.

G. Prevent contamination.

PART 3 EXECUTION

3.1 EXAMINATION

A. Verify that prepared soil base is ready to receive the work of this Section.

3.2 PREPARATION OF SUBSOIL

A. Prepare sub-soil to eliminate uneven areas and low spots. Maintain lines, levels, profiles and contours. Make changes in grade gradual. Blend slopes into level areas.

B. Remove foreign materials, weeds and undesirable plants and their roots. Remove contaminated sub-soil.

C. Scarify subsoil to a depth of 4 inches where topsoil is to be placed. Repeat cultivation in areas where equipment, used for hauling and spreading topsoil, has compacted sub-soil.

3.3 PLACING TOPSOIL

A. Spread topsoil to a minimum depth of 4 inches over area to be seeded. Rake until smooth.

B. Place topsoil during dry weather and on dry unfrozen subgrade.

C. Remove vegetable matter and foreign non-organic material from topsoil while spreading.

D. Grade topsoil to eliminate rough, low or soft areas, and to ensure positive drainage.

E. Install edging at periphery of seeded areas in straight lines to consistent depth.

3.4 FERTILIZING

A. Apply fertilizer in accordance with manufacturer's instructions.

B. Apply after smooth raking of topsoil and prior to roller compaction.

C. For dry placing do not apply fertilizer at same time or with same machine as will be used to apply seed.

D. Lightly water to aid the dissipation of fertilizer.

3.5 SEEDING (Cool Weather Only)

A. Apply seed at a rate of 5 pounds per 1000 square foot evenly in two intersecting directions. Rake in lightly.

B. Do not seed areas in excess of that which can be mulched on same day.

C. Planting Season: September through March, fescue/rye only.

D. Do not sow immediately following rain, when ground is too dry, or during windy periods.

E. Roll seeded area with roller not exceeding 112 pounds.

F. Immediately following seeding and compacting, apply mulch to a thickness of1/8 inches. Maintain clear of shrubs and trees.

G. Apply water with a fine spray immediately after each area has been mulched. Saturate to 3 inches of soil.

3.6 HYDROSEEDING

A. Apply seeded slurry with a hydraulic seeder at a rate of 5 pounds per 1000 square feet evenly in two intersecting directions.

B. Do not hydroseed area in excess of that which can be mulched on same day.

C. Immediately following seeding, apply mulch to a thickness of 1/8 inches. Maintain clear of shrubs and trees.

D. Apply water with a fine spray immediately after each area has been mulched. Saturate to 3 inches of soil.

3.7 MAINTENANCE

A. Mow grass at regular intervals to maintain at a maximum height of 2½ inches. Do not cut more than 1/3 of grass blade at any one mowing.

B. Neatly trim edges and hand clip where necessary.

C. Immediately remove clippings after mowing and trimming.

D. Water to prevent grass and soil from drying out.

E. Immediately reseed areas which show bare spots.

3.8 SCHEDULE

A. All disturbed areas shall be hydromulched with the Normal Application Seed Mixture unless specified otherwise in the Landowner Special Provisions.

END OF SECTION

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