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International Journal of Pavement Engineering Vol. 9, No. 6, December 2008, 413–429

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ABBREVIATIONS AND DEFINITIONS

Abbreviations:

AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
ACPA	American Concrete Pipe Association
AI	Asphalt Institute
AISC	American Institute of Steel Construction
AMRL	AASHTO Materials Reference Laboratory
ANSI	American National Standards Institute
APWA	American Public Works Association
AREMA	American Railway Engineering and Maintenance-of-Way Association
ASCE	American Society of Civil Engineers
ASLA	American Society of Landscape Architects
ASME	American Society of Mechanical Engineers
ASNT	American Society for Nondestructive Testing
ASTM	American Society for Testing and Materials
AWS	American Welding Society
AWWA	American Water Works Association
BMP	Best Management Practices
CFR	Code of Federal Regulations
CMP	Corrugated Metal Pipe
COC	City of Cibolo
COE	U.S. Army Corps of Engineers
CRSI	Concrete Reinforcing Steel Institute
DMS	Departmental Material Specification
EPA	United States Environmental Protection Agency
FHWA	Federal Highway Administration, U.S. Department of Transportation
GSA	General Services Administration
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Organization for Standardization
ITE	Institute of Transportation Engineers
LRFD	Load Resistance Factor Design
NCHRP	National Cooperative Highway Research Program
NEC	National Electrical Code (Published by NFPA)
NEMA	National Electrical Manufacturers Association
NEPA	National Environmental Policy Act
NESC	National Electrical Safety Code
NIST	National Institute of Standards and Technology
NRMCA	National Ready Mixed Concrete Association
OSHA	Occupational Safety & Health Administration, U.S. Department of Labor
PCA	Portland Cement Association
PCI	Precast/Prestressed Concrete Institute
PSI	Pounds Per Square Inch
PPI	Plastics Pipe Institute
RCP	Reinforced Concrete Pipe
RPLS	Registered Public Land Surveyor
RRC	Railroad Commission of Texas
SAE	Society of Automotive Engineers
SI	International System of Units
SSPC	Society for Protective Coatings
TAC	Texas Administrative Code

TCEQ	Texas Commission on Environmental Quality
TDLR	Texas Department of Licensing and Regulation
TMUTCD	Texas Manual on Uniform Traffic Control Devices for Streets and Highways
UL	Underwriters Laboratory, Inc.
USC	United States Code
WRI	Wire Reinforcement Institute

Definitions for Use with the 2013 Cibolo Street Pavement Standards:

1. **Air Temperature.** The temperature measured in degrees Fahrenheit (°F) in the shade, not in the direct rays of the sun, and away from artificial heat.
2. **Arterial.** A road used primarily for through traffic and usually on a continuous route.
3. **Bridge.** A structure, including supports, erected over a depression or an obstruction (e.g., water, a highway, or a railway) having a roadway or track for carrying traffic or other moving loads, and having an opening measured along the center of the roadway of more than 20 ft. between faces of abutments, spring lines of arches, or extreme ends of the openings for multiple box culverts.
4. **City or City of Cibolo.** The governmental entities that comprise the City of Cibolo.
5. **Construction Bulletin C-8.** TxDOT Manual of procedures for driving and test loading piling.
6. **Construction Bulletin C-9.** TxDOT Manual of procedures for constructing & test loading drilled shafts.
7. **Control of Access.** The condition in which the right to access of owners or occupants of abutting land or other persons in connection with a street, roadway, or highway is fully or partially controlled by public authority.
8. **Cross-Sections.** Graphic representations of the original ground and the proposed facility, at right angles to the centerline or base line.
9. **Culvert.** Any buried structure providing an opening under a roadway for drainage or other purposes. Culverts may also be classified as bridges.
10. **Detour.** A temporary traffic route around a closed portion of a road.
11. **Departmental Material Specifications (DMS).** Reference specifications for various materials published by the TxDOT Construction Division.
12. **Direct Traffic Culvert.** Concrete box culvert whose top slab is used as the final riding surface or is to have an overlay or other riding surface treatment.
13. **Engineer.** The City Engineer of the City of Cibolo.
14. **Hazardous Materials or Waste.** Hazardous materials or waste include but are not limited to explosives, compressed gas, flammable liquids, flammable solids, combustible liquids, oxidizers, poisons, radioactive materials, corrosives, etiologic agents, and other material classified as hazardous by 40 CFR 261, or applicable state and federal regulations.
15. **Inspector.** The person assigned by the Engineer to inspect for compliance with the Contract any or all parts of the work and the materials used.
16. **Intersection.** The general area where 2 or more highways, streets, or roads join or cross, including the roadway and roadside facilities for traffic movements within it.
17. **Island.** An area within a roadway from which vehicular traffic is intended to be excluded, together with any area at the approach occupied by protective deflecting or warning devices.
18. **Licensed Professional Engineer.** A person duly licensed by the Texas Board of Professional Engineers to engage in the practice of engineering in the State of Texas.
19. **Local Street or Road.** A street or road primarily for access to residence, business, or other abutting property.
20. **Manual of Testing Procedures.** TxDOT Department manual outlining test methods and procedures maintained by the Materials and Pavements Section of the Construction Division.
21. **Median.** The portion of a divided highway separating the traffic lanes in opposite directions.
22. **Nonhazardous Recyclable Material (NRM).** A material recovered or diverted from the nonhazardous waste stream for the purposes of reuse or recycling in the manufacture of products that may otherwise be produced using raw or virgin materials.
23. **Pavement.** That part of the roadway having a constructed surface for the use of vehicular traffic.

24. **Pavement Structure.** Combination of surface course and base course placed on a subgrade to support the traffic load and distribute it to the roadbed.
 - A. **Surface Course.** Pavement structure layers designed to accommodate the traffic load. The top layer resists skidding, traffic abrasion, and the disintegrating effects of climate and is sometimes called the wearing course.
 - B. **Base Course.** One or more layers of specified material thickness placed on a subgrade to support a surface course.
 - C. **Subgrade.** The top surface of a roadbed upon which the pavement structure, shoulders, and curbs are constructed.
 - D. **Subgrade Treatment.** Modifying or stabilizing material in the subgrade.
25. **Plans.** The drawings approved by the Engineer including true reproductions of the drawings that show the location, character, dimensions, and details of the work and are a part of the Contract.
26. **Right of Way.** A general term denoting land or property devoted to transportation purposes.
27. **Roadbed.** The graded portion of a highway prepared as foundation for the pavement structure and shoulders. On divided highways, the depressed median type and the raised median type highways are considered to have 2 roadbeds. Highways with a flush median are considered to have 1 roadbed.
28. **Roadside.** The areas between the outside edges of the shoulders and the right of way boundaries. Unpaved median areas between inside shoulders of divided highways and areas within interchanges are included.
29. **Roadway.** The portion of the highway (including shoulders) used by the traveling public.
30. **Sidewalk.** Portion of the right of way constructed exclusively for pedestrian use.
31. **Special Provisions.** Additions or revisions to these standard specifications or special specifications.
32. **Specifications.** References to TxDOT DMSs, ASTM or AASHTO specifications, or TxDOT bulletins and manuals, imply the latest standard or tentative standard in effect on the date of the proposal. The Engineer will consider incorporation of subsequent changes to these documents in the project Scope of Work.
33. **State.** The State of Texas.
34. **Station.** A unit of measurement consisting of 100 horizontal feet.
35. **Substructure.** The part of the structure below the bridge seats or below the springing lines of arches. Parapets, back walls, and wing walls of abutments are considered as parts of the substructure.
36. **Superstructure.** The part of the structure above the bridge seats or above the springing lines of arches.
37. **Traffic Lane.** The strip of roadway intended to accommodate the forward movement of a single line of vehicles.
38. **Utility.** Privately, publicly, or cooperatively owned lines, facilities, and systems for producing, transmitting, or distributing communications, power, heat, gas, oil, water, waste, or storm water that are not connected with the highway drainage, signal systems, or other products that directly or indirectly serve the public; the utility company.

DIVISION I - EARTHWORK

ITEM 101 STREET EXCAVATION

101.1. CONSTRUCTION: The subgrade shall be shaped in conformity to the lines and grades established by the Engineer by removal of existing material or addition of approved material. Material removed in one area may be utilized in the addition of material to the subgrade in another area if approved by the Engineer. All material required for completion of the subgrade shall be subject to approval by the Engineer.

Unsuitable excavation or excavation in excess of that needed for construction shall be known as "Waste" and shall become the property of the Contractor and it shall become his sole responsibility to dispose of this material off the limits of the right-of-way. Proper disposal shall be in conformance with, but not limited to, the following provisions:

- Do not deposit excavated material within regulatory wetlands, and
- Obtain appropriate permits and apply provisions pertaining to soil erosion and stream pollution, when necessary, to meet federal and/or local regulations, rules, and procedures.

A. Rock Cuts. Excavate to finished subgrade elevation using equipment appropriate for the conditions encountered. Manipulate and compact subgrade in accordance with the below "Compaction" standards, unless excavation is to clean homogenous rock at finished subgrade elevation. If excavation extends below finished subgrade, use approved material compacted to replace undercut material. All unstable or otherwise objectionable material shall be removed from the subgrade and replaced with approved material in loose lifts not to exceed 12 inches in depth.

B. Earth Cuts. All earth cuts shall be scarified to a uniform depth of at least 6-inches below the required finished subgrade elevation. All holes, ruts, and depressions shall be filled with approved material in loose lifts not to exceed 12 inches in depth. Compact the scarified subgrade in accordance with Section 101.1.C, "Compaction."

If the Engineer determines that the subgrade is unsuitable, the contractor shall remove the unsuitable material to the limits directed by the Engineer and replace it with suitable material.

C. Compaction. Subgrade materials shall be compacted to the required density and moisture content as shown below, unless otherwise shown on the plans:

Subgrade Material	Density	Moisture Content
PI ≤ 20	≥ 95% of Max Dry Density	- 2% of Opt. or greater
PI > 20	≥ 95% of Max Dry Density	≥ Opt. Moisture

The maximum dry density and optimum moisture content shall be determined in accordance with TxDOT Test Method Tex-114-E. Tests for in place density shall be made in accordance with TxDOT Test Method Tex-115-E and within 24 hours after compacting operations are completed. If the material fails to meet the density specified, it shall be re-worked as necessary to obtain the density required.

For materials with a PI > 20, just prior to placing any base materials or stabilization, the top 3 inches of compacted subgrade shall be tested for density and moisture content. If tests show the density to be more than 2% below the specified minimum or the moisture content to be

more than 3% above or below the optimum, the course shall be reworked as necessary to obtain the specified compaction and moisture content.

If the material used to replace undercuts or unsuitable material contains more than 30% oversize fraction (i.e. 30% or more retained on the ¾-inch sieve) or is gap-graded (many large particles with limited small particles), the maximum density determined by Tex-114-E may not be appropriate for field compaction. If this situation is encountered, the Engineer may elect to accept the material without density testing. With the approval of the Engineer, place layers in loose lifts not to exceed 12 inches. Before and during rolling operations, bring each layer to the moisture content directed. Compact each layer until there is no evidence of further consolidation. Maintain a level layer to aid in uniform compaction. If the required stability or finish is lost for any reason, re-compaction and refinishing of the subgrade is required.

D. Tolerances. The surface of the subgrade shall be finished to the lines and grades as established. Any deviation in excess of ½-inch in cross section and in a length of 16-feet measured longitudinally shall be corrected by loosening, adding, or removing material, reshaping and compacting by sprinkling and rolling in accordance with Section 104.4.C., "Compaction." Sufficient subgrade shall be prepared in advance to insure satisfactory prosecution of the work.

E. Quality Control. After each layer of embankment or select material is complete, the City Engineer may require tests as necessary to ensure compliance with these standards. If the material fails to meet the density specified, the course shall be reworked, as necessary, to obtain the specified compaction.

Should the subgrade, due to any reason or cause, lose the required stability, density/moisture as described in Section 101.1.C, "Compaction" or finish before the pavement is placed, it shall be re-compacted in accordance with Section 101.1C and refinished. Excessive loss of moisture in the subgrade shall be prevented by sprinkling, sealing or covering with a subsequent layer of asphaltic or other approved material.

ITEM 102 CHANNEL EXCAVATION

102.1. DESCRIPTION: *Excavate open channels within the limits shown on the plans, regardless of the type of material encountered, and dispose of any unused excavated materials. Construct, shape and finish all earthwork involved in conformance with the required lines, grades and cross sections, and in accordance with the plans and specification requirements.*

Note: This item does not apply to excavation required for box culvert conduits, cast-in-place or precast pipe storm sewers, or for pipe sanitary sewers as excavation for those types of construction are governed by the conditions set forth in other specification items. Excavation for other small drainage structures shall be governed under Item 306, "Structural Excavation", when indicated on the plans. Such excavation will be considered as that beyond the limits of the channel excavation as indicated on the plans.

102.2. MATERIALS: All excavation shall be unclassified and shall include all materials encountered regardless of their nature or the manner in which they are removed.

A. Hazardous Materials. If hazardous substances, industrial waste, other environmental pollutants, underground storage tanks, or conditions conducive to environmental damage are encountered, the excavation shall immediately cease in the area affected and report to the City Engineer and all other agencies with jurisdiction.

B. Existing Structures/Obstructions. Removal of structures and other obstructions prior to excavation and finishing of all other earthwork described herein shall be completed.

C. Existing Asphaltic Materials. All asphaltic material shall be disposed of or recycled at a facility authorized to accept the material for such purposes.

102.3. EQUIPMENT: Provide applicable equipment to conduct work as described in this specification or as specified on the plans.

102.4. CONSTRUCTION: All channel excavation shall be performed as shown on the plans, or specified herein if not denoted on the plans, and shall conform to the established alignment, grades and cross sections. Suitable excavated materials shall be utilized, insofar as practicable, in constructing required embankments, or backfilling around drainage structures.

Unsuitable excavation or excavation in excess of that needed for construction shall be known as "Waste" and shall become the property of the Contractor and it shall become his sole responsibility to dispose of this material off the limits of the right-of-way. Proper disposal shall be in conformance with, but not limited to, the following provisions:

1. Do not deposit excavated material within jurisdictional wetlands, and
2. Obtain appropriate permits and apply provisions pertaining to soil erosion and stream pollution, when necessary, to meet federal and/or local regulations, rules, and procedures.

A. Temporary Construction Access. Any temporary construction access that crosses a channel will be constructed so as to allow a continuous flow at all times. The channel flow line will not be blocked or raised at any temporary construction access.

B. Channel Side Slope (Fill). When the plans indicate fill of a channel side slope, the fill material shall be placed in layers not to exceed 12 inches and shall be benched or notched into existing slopes. Each lift of fill shall be compacted to the required density and moisture content as shown below, unless otherwise shown on the plans:

Subgrade Material	Density	Moisture Content
PI ≤ 20	≥ 95% of Max Dry Density	- 2% of Opt. or greater
PI > 20	≥ 95% of Max Dry Density	≥ Opt. Moisture

The maximum dry density and optimum moisture content shall be determined in accordance with TxDOT Test Method Tex-114-E. Tests for in place density shall be made in accordance with TxDOT Test Method Tex-115-E and within 24 hours after compacting operations are completed. If the material fails to meet the density specified, it shall be re-worked as necessary to obtain the density required.

The fill material shall be free from roots, trash, silt and objectionable debris and shall be approved by the Engineer. The channel side slopes, in fill areas, shall be cut to the finished dimensions after completion of the fill process.

- C. Lateral Ditches.** At locations where lateral ditches enter the channel, the Contractor shall perform grading as may be required to maintain lateral ditch side slopes within the easement area. The cost of all grading shall be considered incidental to the unit price bid and no extra payment will be made.
- D. Channel Completion.** Prior to final acceptance by the Engineer, the Contractor shall remove all sediment from the bottom of the channel and dispose of this material off site. The cost of sediment removal and grading shall be incidental to the unit price bid, and no extra payment will be made. Revegetation is not required on channels primarily composed of rock.

ITEM 103 EMBANKMENT

103.1. DESCRIPTION: *Furnish, place, and compact materials for construction of roadways, embankments, levees, or any section of a roadway where additional material is required.*

103.2. 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 material meeting the requirements of Type B unless one or more of the following types is shown on the plans or directed by the Engineer:

A. 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	TxDOT Standard Laboratory Test Procedure	Specification Limit
Liquid limit	Tex-104-E	≤ 45
Plasticity index (PI)	Tex-106-E	≤ 15
Bar linear shrinkage	Tex-107-E	≥ 2

The Linear Shrinkage test only needs to be performed as indicated in TxDOT standard laboratory test procedure Tex-104-E.

B. Type B. Materials such as rock, loam, clay, or other approved materials.

C. Type C. Material meeting the specification requirements shown on the plans.

D. Type D. Material from required excavation areas shown on the plans.

Retaining wall backfill material must meet the requirements of the pertinent retaining wall Items.

103.4. CONSTRUCTION: 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 TxDOT 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-inches, 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 the "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.

A. 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.

Obtain approval to incorporate rock and broken concrete produced by the construction project

in the lower layers of the embankment. When the size of approved rock or broken concrete exceeds the layer thickness requirements in the “Compaction Methods” specifications, place the rock and concrete outside the limits of the completed roadbed. 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. Featheredged or mix abutting layers of dissimilar material for at least 100-feet 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.

When ordinary compaction is specified, roll and sprinkle each embankment layer in accordance with Section 107.3.D.1, “Ordinary Compaction.” When density control is specified, compact the layer to the required density in accordance with Section 107.3.D.2, “Density Control.” When rock and broken concrete are allowed in lower layers of earth embankments, proof-roll these layers as directed where density testing is not possible, in accordance with TxDOT Item 216, “Proof Rolling” to ensure proper compaction.

- B. 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-inches or less. Increase the layer depth for large rock sizes as approved. Do not exceed a depth of 2½ feet 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 feet 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 107.3.D, “Compaction Methods.” Break up exposed oversized material as approved.

When ordinary compaction is specified, roll and sprinkle each embankment layer in accordance with Section 107.3.D.1, “Ordinary Compaction.” When density control is specified, compact each layer to the required density in accordance with “Density Control” standard. Proof-roll each rock layer where density testing is not possible, in accordance with TxDOT Item 216, “Proof Rolling” to ensure proper compaction.

- C. Embankments Adjacent to Culverts and Bridges.** Compact embankments adjacent to culverts and bridges in accordance with Item 106, “Box Culvert Excavation and Backfilling.”
- D. Compaction Methods.** Begin rolling longitudinally at the sides and proceed toward the center, overlapping on successive trips by at least ½ the width of the roller. On super elevated curves, begin rolling at the lower side and progress toward the high side. Alternate roller trips to attain slightly different lengths. Compact embankments in accordance with one of the following methods as shown on the plans:

- 1. Ordinary Compaction.** Use approved rolling equipment complying with Item 210, “Rolling,” to compact each layer. The plans or the Engineer may require specific equipment. Do not allow the loose depth of any layer to exceed 12 inches, unless otherwise approved. Before and during rolling operations, bring each layer to the moisture content directed. Compact each layer until there is no evidence of further consolidation. Maintain a level layer to ensure uniform compaction. If the required stability or finish is lost for any reason, recompact and refinish the subgrade at no additional expense to the City.

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 12 inches loose material, unless otherwise approved. Maintain a level layer to ensure uniform compaction.

The Engineer will use TxDOT standard laboratory test procedure 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.

When required, remove small areas of the layer to allow for density tests. Replace the removed material and recompact. Proof-roll in accordance with TxDOT Item 216, "Proof Rolling," when shown on the plans or as directed. Correct soft spots as directed.

- E. **Maintenance of Moisture and Reworking.** Maintain the density and moisture content once all requirements in Table 2 are met. For soils with a PI greater than 15, maintain the moisture content no lower than 4 percentage points below optimum. 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.

F. Acceptance Criteria.

1. Grade Tolerances.

- a. **Staged Construction.** Grade to within 0.1-foot in the cross-section and 0.1-foot in 16-feet measured longitudinally.
- b. **Turnkey Construction.** Grade to within ½-inch in the cross-section and ½-inch in 16-feet measured longitudinally.

2. **Gradation Tolerances.** When gradation requirements are shown on the plans, material is acceptable when not more than 1 of the 5 most recent gradation tests is outside the specified limits on any individual sieve by more than 5 percentage points.

3. **Density Tolerances.** Compaction work is acceptable when not more than 1 of the 5 most recent density tests is outside the specified density limits, and no test is outside the limits by more than 3 lb. per cubic foot.

4. **Plasticity Tolerances.** Material is acceptable when not more than 1 of the 5 most recent PI tests is outside the specified limit by no more than 2 points.

ITEM 104 LIME TREATED SUBGRADE

- 104.1. DESCRIPTION:** *The use of lime treated subgrade is **highly discouraged** at most locations in Cibolo. However, should there be a location where the use of lime treated subgrade is recommended by geotechnical analysis due to unique conditions at that location, the City Engineer may consider a lime treated subgrade..*

Treat the subgrade by pulverizing, adding lime, mixing, and compacting to the required density. This item applies to both natural ground and embankment subgrade and shall be constructed as specified herein and in conformance with the typical sections, lines and grades as shown on the plans or as established by the Engineer.

- 104.2. MATERIALS:** Lime for this item shall conform to the requirements of TxDOT Item No. 260, "Lime Treatment – Road Mixed" of the Texas Department of Transportation Standard Specifications (Latest Edition). Acceptable forms of lime shall be:

- "Type A, Hydrated Lime,"
- "Type B, Commercial Lime Slurry," or
- "Type C, Quicklime."

The Contractor shall select, prior to construction, the grade to be used and shall notify the Engineer in writing before changing from one grade to another. Lime shall be placed in slurry form only, unless written permission is granted by the Engineer and a safety and containment plan is submitted to the Engineer by the Contractor seven days prior to use. In circumstances where it would be beneficial to utilize lime for "drying" subgrade materials to expedite construction, the Contractor may request approval from the Engineer to use pelletized lime.

Provide materials in conformance with the following Items and requirements:

A. Lime. TxDOT DMS-6350 "Lime and Lime Slurry."

B. Mix Design. The Engineer will determine the target lime content and optimum moisture content in accordance with TxDOT Tex -121-E.

- 104.3. EQUIPMENT:** The machinery, tools and equipment necessary for proper prosecution of the work shall be on the project and approved by the Engineer prior to the beginning of construction operations. All machinery, tools and equipment used shall be maintained in a satisfactory and workmanlike manner.

When lime is furnished in trucks, the weight of lime shall be determined on certified scales and delivered to the job site with exit ports sealed at the plant.

- 104.4. CONSTRUCTION:**

A. General. The completed course shall be uniformly treated, free from loose or segregated areas, of uniform density and moisture content, well bound for its full depth and shall have a smooth surface.

B. Preparation of Subgrade or Existing Base. Prior to treating existing material, it shall be shaped to conform to the typical sections, as shown on the plans.

Before pulverizing or scarifying an existing material, when directed by the Engineer, the Contractor shall proof roll the roadbed in accordance with TxDOT Item 216, "Proof Rolling."

Soft spots shall be corrected as directed by the Engineer. When the Contractor elects to use a cutting and pulverizing machine that will process the material to the plan depth, the Contractor will not be required to excavate to the secondary grade or windrow the material. This method will be permitted only if a machine is provided which will insure that the material is cut uniformly to the proper depth and which has cutters that will plane the secondary grade to a uniform surface over the entire width of the cut. The machine shall provide a visible indication of the depth of cut at all times.

In lieu of using the cutting and pulverizing machine, the Contractor shall excavate and windrow the material to expose the secondary grade to the typical sections, lines and grades as shown on the plans or as established by the Engineer.

- C. Pulverization.** The existing pavement or base material shall be pulverized or scarified so that 100 % shall pass the 2-½ inch sieve.
- D. Application.** The percentage by weight or pounds per square yard of lime to be added will be as shown on the plans and may be varied by the Engineer if conditions warrant.

Lime shall be spread only on that area where the mixing operations can be completed during the same working day.

Unless otherwise approved by the Engineer, the lime operation shall not be started when the air temperature is below 40°F and falling, but may be started when the air temperature is above 35°F and rising. The temperature will be taken in the shade and away from artificial heat. Lime shall not be placed when weather conditions in the opinion of the Engineer are unsuitable.

The application and mixing of lime with the material shall be accomplished by the methods herein described as "Slurry Placing." "Dry Placing" is not allowed unless approved by the Engineer as described in Section 108.2, "Materials." Type A, Hydrated Lime shall be applied by "Slurry Placing" unless otherwise shown on the plans or approved by the Engineer. Type B Commercial Lime Slurry shall be applied by "Slurry Placing." Type C Quicklime shall be applied by "Slurry Placing" only. "Dry Placing" will not be allowed unless approved by the Engineer. When Type C Quicklime is used for dry placement, it shall be Grade "DS." When Type C Quicklime is used for slurry placement, it shall be either Grade "DS" or Grade "S." Grade "S" shall be used in slurry placement only.

- 1. Slurry Placing.** When Type A Hydrated Lime is specified and slurry placement is to be used, the Type A Hydrated Lime shall be mixed with water to form a slurry with a solids content approved by the Engineer.

Type B Commercial Lime Slurry shall be delivered to the project in slurry form at or above the minimum dry solids content approved by the Engineer. The distribution of lime at the rate(s) shown on the plans or approved by the Engineer shall be attained by successive passes over a measured section of roadway until the proper lime content has been secured.

When Type C Quicklime is applied as slurry, the amount of dry quicklime shall be 80 percent of the amount shown on the plans. The slurry shall contain at least the minimum dry solids content approved by the Engineer. The residue from the slurring procedure shall be spread uniformly over the length of the roadway currently being processed unless otherwise approved by the Engineer. This residue is primarily inert material with little stabilizing value, but may contain a small amount of quicklime particles that slake slowly. A concentration of these particles could cause the compacted stabilized material to swell during slaking.

Slurry shall be of such consistency that it can be applied uniformly without difficulty.

When the distributor truck is not equipped with an agitator, the Contractor shall have a standby pump available on the project for agitating the lime and water as required by the Engineer in case of undue delays in dispersing the slurry.

2. **Dry Placing.** Dry placing is not allowed unless approved by the Engineer as described in Section 108.2, "Materials." If allowed, the lime shall be distributed by an approved spreader at the rate shown on the plans or as directed by the Engineer. The lime shall be distributed at a uniform rate and in such a manner as to reduce the scattering of lime by the wind. The material shall be sprinkled as approved by the Inspector.

- E. Mixing.** The mixing procedure shall be the same for "Slurry Placing" or "Dry Placing" as herein described.

Begin Mixing within 6 hours of lime application. During the interval between application and mixing, hydrated lime that has been exposed to the open air for a period of six (6) hours or more or to excessive loss due to washing or blowing will not be accepted for payment.

1. **Initial Mixing.** The material and lime shall be thoroughly mixed. The material and lime shall be brought to the proper moisture content and left to mellow for 1 to 4 days. When pebble grade quicklime is used, allow the mixture to mellow for 2 to 4 days as approved by the Engineer.

In addition to the above, when Type C Quicklime, Grade "DS," is approved for use by the Engineer under "Dry Placing," the material and lime shall be mixed as thoroughly as possible at the time of the lime application. Sufficient moisture shall be added during the mixing to hydrate the quicklime.

During the mellowing period, the material shall be kept moist as directed by the Inspector.

When shown on the plans or approved by the Engineer, the pulverization requirement may be waived when the material contains a substantial quantity of aggregate.

2. **Final Mixing.** After the required mellowing time, the material shall be uniformly mixed by approved methods. If the soil binder-lime mixture contains clods, they shall be reduced in size by the use of approved pulverization methods.

Following mixing, a sample of the material at roadway moisture will be obtained for pulverization testing. All non-slaking aggregates retained on the ¾ inch sieve will be removed from the sample. The remainder of the material shall meet the following pulverization requirement when tested by TXDOT Test Method Tex-101-E, Part III:

Minimum passing 1 ¾" sieve	100
Minimum passing ¾" sieve	85
Minimum passing No. 4 sieve	60

- F. Compaction.** Prior to compaction, the material shall be aerated or sprinkled as necessary to provide the optimum moisture. Compaction of the mixture shall begin immediately after final mixing and in no case more than 24 hours after final mixing.

Compaction shall continue until the entire depth of the mixture is uniformly compacted. Throughout this entire operation, the shape of the course shall be maintained by blading, and the surface upon completion shall be smooth and in conformity with the typical sections, lines

and grades as shown on the plans or as established by the Engineer.

1. **Ordinary Compaction.** Roll with approved compaction equipment, as directed. Correct irregularities, depressions, and weak spots immediately by scarifying the areas affected, adding or removing treated material as required, reshaping, and recompacting.
2. **Density Control.** Each course shall be sprinkled as required and compacted to the extent necessary to provide not less than 95 percent of the optimum density. Unless otherwise shown on the plans, the Engineer will determine roadway density of completed sections in accordance with TxDOT Test Method 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.

When the material fails to meet the density requirements, or should the material lose the required stability, density or finish before the next course is placed, or the project is accepted, it shall be reworked as specified below.

G. Reworking a Section. When a section is reworked within 72 hours after completion of compaction, the Contractor shall rework the section to provide the required compaction. When a section is reworked more than 72 hours after completion of compaction, the Contractor shall add 25 percent of the specified rate of lime. Reworking shall include loosening, road mixing as approved by the Engineer, compacting, and finishing. When a section is reworked, a new optimum density will be determined from the reworked material in accordance with TXDOT Test Method Tex-121-E, part II and shall compact in-place to a minimum of 95% of this density.

H. Finishing. Immediately after completing compaction, clip, skin, or tight-blade the surface of the lime treated material with a maintainer or subgrade trimmer to a depth of approximately ¼-inch. Remove loosened material and dispose of it at an approved location. Roll the clipped surface immediately with a pneumatic-tire roller until a smooth surface is attained. Add small increments of water as needed during rolling. Shape and maintain the course and surface in conformity with the typical sections, lines and grades shown on the plans or as directed.

Finish grade of constructed subgrade in accordance with the following grade tolerances

1. **Staged Construction.** Grade to within 0.1-foot in the cross-section and 0.1-foot in 16-foot measured longitudinally.
2. **Turnkey Construction.** Grade to within ½-inch in the cross-section and ½-inch in 16-foot measured longitudinally.

Do not surface patch.

I. Curing. After the final layer or course of the lime treated material has been compacted, it shall be brought to the required lines and grades in accordance with the typical sections.

The completed section shall then be finished by rolling with a pneumatic tire or other suitable roller. The completed section shall be moist cured or prevented from drying by addition of an asphalt material at the rate of 0.05 to 0.20 gallons per square yard. Curing shall continue for 2 to 5 days before further courses are added or traffic is permitted, unless otherwise approved by the Engineer.

However, the lime treated material may be covered by other courses, the day following finishing, when approved by the Engineer. When the plans provide for the treated material to be covered by other courses of material, the next course shall be applied within 14 calendar days after final compaction is completed, unless otherwise approved by the Engineer.

ITEM 105

CEMENT TREATED SUBGRADE

105.1. DESCRIPTION: *Treat natural subgrade or fill materials used to meet the top of subgrade profile, by the addition of Portland cement and water. Pulverize, mix, and compact the mixed material to the required density, as herein specified and in conformance with the typical sections, lines, grades and thickness as shown on the plans.*

105.2. MATERIALS: Soil shall consist of approved material, free from vegetation or other objectionable matter, encountered in the roadbed section and other acceptable material used in the preparation of the roadbed in accordance with this specification. 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 TxDOT standard laboratory test procedure Tex-100-E for material definitions.

Cement shall be placed in slurry form only, unless written permission is granted by the Engineer and a safety and containment plan is submitted to the Engineer by the Contractor seven days prior to use.

A. Cement. Furnish hydraulic cement that meets the requirements of TxDOT's DMS 4600, "Hydraulic Cement," TxDOT's Hydraulic Cement Quality Monitoring Program (HCQMP), and ASTM C-150 Type I Portland Cement. Sources not on the HCQMP or other sources to be used in combination with an approved source will require approval before use.

B. Flexible Base. When treating entirely new base, furnish material that meets the requirements of Item 200, "Flexible Base," for the type and grade shown on the plans, before the addition of cement. When treating existing flexible base, with or without existing asphalt concrete pavement, the material shall conform to the requirements shown on the plans. Incorporate new base with the existing materials when shown on plans.

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

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

E. Mix Design. The Engineer will determine the target cement content and optimum moisture content to produce a treated mixture that meets the strength requirements shown on the plans. The mix will be designed in accordance with TxDOT standard laboratory test procedure Tex-120-E or will be based on prior experience with the project materials. The Contractor may propose a mix design developed in accordance with TxDOT standard laboratory test procedure Tex-120-E. The Engineer, at their discretion, will use TxDOT standard laboratory test procedure Tex-120-E to verify the Contractor's proposed mix design before acceptance. Reimburse the City for subsequent mix designs or partial designs necessitated by changes in the material or requests by the Contractor, when the City performs these services. When treating existing materials, limit the amount of asphalt concrete pavement to no more than 50% of the mix unless otherwise shown on the plans or directed.

105.3. 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 TxDOT Item 216, "Proof Rolling," when required.

A. Cement Storage Facility. Store cement in closed, weatherproof containers.

B. Cement Slurry Equipment. Use slurry tanks equipped with agitation devices to slurry cement on the project or other approved location. The Engineer may approve other slurring methods. Provide a pump for agitating the slurry when the distributor truck is not equipped with an agitator. Equip the distributor truck with an approved sampling device.

C. Pulverization Equipment. Provide pulverization equipment that:

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

105.4. 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.

A. Preparation of Subgrade for Treatment. Shape natural subgrade or fill material in accordance with applicable bid items to conform to the typical sections shown on the plans and as directed.

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

B. Pulverization. Pulverize or scarify existing material after shaping so that 100% passes a 2½ inch 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.

C. Application of Cement. Uniformly apply cement using slurry placement unless approved by the Engineer. Add cement at the percentage determined in Section 201.2.E, "Mix Design." Apply cement only on an area where mixing, compacting, and finishing can be completed during the same working day.

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

1. Slurry Placement. Mix the required quantity of cement with water, as approved. Provide slurry free of objectionable materials and with a uniform consistency that can be easily applied. Agitate the slurry continuously. Apply slurry within 2 hours of adding water and when the roadway is at a moisture content drier than optimum. Distribute slurry uniformly by making successive passes over a measured section of the roadway until the specified cement content is reached.

2. Dry Placement. Dry placement shall not be allowed unless approved by the Engineer as described in Section 109.2, "Materials." If used, before applying cement, bring the prepared roadway to approximately optimum moisture content. When necessary, sprinkle in accordance with TxDOT Item 204, "Sprinkling." Distribute the required quantity of dry cement with approved equipment. Minimize dust and scattering of cement by wind. Do not apply cement when wind conditions, in the opinion of the Engineer, cause blowing cement to become dangerous to traffic or objectionable to adjacent property owners.

D. Mixing. The mixing procedure shall be the same for "Slurry Placing" or "Dry Placing" as

herein described. Thoroughly mix the material and cement using approved equipment. Mix until a homogeneous mixture is obtained. If required, sprinkle the treated materials during the mixing operation to maintain optimum mixing moisture. Spread and shape the completed mixture in a uniform layer.

After mixing, the Engineer will sample the mixture at roadway moisture and test in accordance with TxDOT standard laboratory test procedure Tex-101-E, Part III, to determine compliance with the gradation requirements in Table 1.

Table 1
Gradation Requirements Minimum % Passing

Sieve Size	Subgrade
1-¾ in.	100
¾ in.	85
No. 4	60

- E. Compaction.** Compact the mixture in one lift using density control unless otherwise shown on the plans. Complete compaction within 2 hours after the application of cement.

Sprinkle or aerate the treated material in accordance with TxDOT Item 204, “Sprinkling,” to adjust the moisture content during compaction so that it is within 2.5 percentage points of optimum as determined by TxDOT standard laboratory test procedure Tex-120-E. Determine the moisture content of the mixture at the beginning and during compaction in accordance with TxDOT standard laboratory test procedure Tex-103-E. Adjust operations as required.

Begin rolling longitudinally at the sides and proceed towards the center, overlapping on successive trips by at least one-half the width of the roller unit. On 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.

Remove areas that lose required stability, compaction, or finish. Replace with cement-treated mixture at the Contractor’s expense.

1. **Ordinary Compaction.** Roll with approved compaction equipment, as directed. Correct irregularities, depressions, and weak spots immediately by scarifying the areas affected, adding or removing treated material as required, reshaping, and recompacting.
2. **Density Control.** Compact to at least 95% of the maximum density determined in accordance with TxDOT standard laboratory test procedure Tex-120-E at a frequency of one test performed per 300 linear feet of paving for two lanes. The Engineer will determine roadway density in accordance with TxDOT standard laboratory test procedure Tex-115-E and, if shown on the plans, will verify strength in accordance with TxDOT standard laboratory test procedure Tex-120-E. Remove material that does not meet density requirements. Remove areas that lose required stability, compaction, or finish. Replace with cement-treated mixture and compact and test in accordance with density control methods.

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 pounds per cubic foot below the specified density.

- F. Finishing.** Immediately after completing compaction, clip, skin, or tight-blade the surface of the cement treated material with a maintainer or subgrade trimmer to a depth of approximately ¼-inch. Remove loosened material and dispose of it at an approved location. Roll the clipped surface immediately with a pneumatic-tire roller until a smooth surface is attained. Add small increments of water as needed during rolling. Shape and maintain the

course and surface in conformity with the typical sections, lines and grades shown on the plans or as directed.

Finish grade of constructed subgrade in accordance with the following grade tolerances:

1. **Staged Construction.** Grade to within 0.1 foot in the cross-section and 0.1 foot in 16-foot measured longitudinally.
2. **Turnkey Construction.** Grade to within ½ inch in the cross-section and ½ inch in 16-foot measured longitudinally.

Do not surface patch.

- G. Curing.** Cure for at least 3-days by sprinkling in accordance with TxDOT Item 204, “Sprinkling,” or by applying an asphalt material at the rate of 0.05 to 0.20 gallons per square yard, as shown on the plans or directed. Maintain the moisture content during curing at no lower than 2.5 percentage points below optimum. Do not allow equipment on the finished course during curing except as required for sprinkling, unless otherwise approved. Continue curing until placing another course or opening the finished section to traffic.

ITEM 106

BOX CULVERT EXCAVATION AND BACKFILLING

106.1. DESCRIPTION: *Excavate and place storm drainage box culverts, whether cast-in-place or precast, within the limits shown on the plans, regardless of the type of material encountered. Remove and satisfactorily dispose all unused excavated materials. Construct, shape, backfill, and finish all earthwork in conformance with the required lines, grades and cross sections in accordance with the plans and specification requirements contained herein.*

Note: This item does not apply to excavation of open channels, or that required for pipe storm sewers or pipe sanitary sewers as excavation for those types of construction are governed by the conditions set forth in their respective specification requirements. Excavation for other small drainage structures shall be governed and paid for under other appropriate items or under Item 306, "Structural Excavation," when indicated on the plans. Such excavation will be considered as that beyond the limits of box culvert excavation as indicated on the plans. Where a box culvert is used as a bridge in open channel construction, excavation shall be governed by Item 105, "Channel Excavation" and as Item 306, "Structural Excavation" beyond the limits of the channel excavation.

106.2. MATERIALS: All box culvert excavation will be unclassified, and shall include all materials encountered regardless of their nature or the manner in which they are removed. Use materials that meet the requirements of the following Items, when indicated on the plans or required:

- A. Flexible Base.**
- B. Subgrade Filler.**
- C. Cement Stabilized Sand.**
- D. Flowable Fill.**
- E. Filter Fabric.**

106.3. EQUIPMENT: Provide applicable equipment to conduct work as described in this specification or as specified on the plans.

106.4. CONSTRUCTION:

- A. General.** All box culvert excavation shall be performed as specified herein and shall conform to the established alignment, grades and cross sections or other limits indicated in the plans.
- B. Safety.** Provide slopes, benching, sheeting, bracing, pumping, and bailing as necessary to maintain the stability and safety of excavations.
- C. Excavation.** Suitable excavated materials shall be utilized, insofar as practicable, in backfilling around the box culvert, or other drainage structures or in constructing required embankments, if applicable. Unsuitable materials below footing grade shall be removed and replaced with gravel subgrade filler.

Excavated materials which are unsuitable for embankments or backfilling, or excavation in excess of that needed for construction shall become the property of the Contractor and it shall become his sole responsibility to properly dispose of this material outside the limits of the project. Proper disposal shall be in conformance with, but not limited to, the following provisions:

- Do not deposit excavated material within jurisdictional wetlands, and
- Obtain appropriate permits and apply provisions pertaining to soil erosion and stream

pollution, when necessary, to meet federal, state, and/or local regulations, rules, and procedures.

1. **Hazardous Materials.** If hazardous substance, waste, environmental pollutants, underground storage tanks, or any other conditions conducive to environmental damage is encountered, work shall cease immediately in the area affected and the condition reported to the City Engineer and other governing agency with jurisdiction.
2. **Existing Structures/Obstructions.** Removal of structures and other obstructions prior to excavation and finishing of all other earthwork described herein shall be completed.
3. **Existing Asphaltic Materials.** All asphaltic material shall be disposed of or recycled at a facility authorized to accept the material for such purposes.
4. **Excavation in Streets.** When structures are installed in streets, highways, or other paved areas, cut pavement and base in accordance with Item 230, "Base and Pavement Replacement." of this criteria after completion of excavation and backfilling in accordance with Item 230, "Base and Pavement Replacement."

Unless otherwise shown on the plans, maintain and control traffic in accordance with the approved traffic control plan or in conformance with the latest edition of the Texas MUTCD.

5. **Utilities.** Conduct work with minimum disturbance of existing utilities, and coordinate work in or near utilities with the utility owners. Inform utility owners sufficiently before work begins to allow them 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. If damage occurs, promptly notify the utility company. If an active sanitary sewer line is damaged during excavation, provide temporary flumes across the excavation while open, and restore the lines when backfilling has progressed to the original bedding lines of the cut sewer.

6. **De-Watering.** Do not construct or place structures in the presence of water unless approved. Place precast units or poured structural concrete only on a dry, firm surface. Remove water by bailing, pumping, well-point installation, deep wells, underdrains, or other approved method.

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

If the bottom of an excavation cannot be de-watered to the point that the subgrade is free of mud or it is difficult to keep reinforcing steel clean, place a stabilizing material in the bottom of the excavation. Stabilizing material may be flexible base, controlled low strength material, flowable backfill, or other material approved by the Engineer.

- D. **Backfilling.** Backfilling to the top of the box culvert (initial backfill) shall be completed by one of the four methods 1., 2., 3., or 4. below. Backfilling from the top of the culvert to the top of the trench (secondary backfill), or proposed subgrade elevation, shall be completed in accordance with Item 400, "Excavation, Trenching, and Backfilling." Backfill behind cast-in-

place culvert walls shall not begin until the concrete has attained a compressive strength of 2,000 psi. Backfill on top of cast-in-place supporting slabs shall not begin until the concrete has attained a compressive strength of 3,000 psi. Avoid wedging action of backfill against structures. If necessary to prevent such action, step or serrate slopes bounding the excavation. Place backfill along both sides of culverts equally and in uniform layers.

- 1. Suitable On-Site Excavated Material.** Material for backfill shall be placed in uniform layers not more than 12 inches in depth (loose measurement) and shall be compacted to the density specified herein. Each layer of backfill material, if dry, shall be wetted uniformly to the moisture content required to obtain the specified density and shall be compacted to the required density, by means of a mechanical tamper.

Each lift of fill shall be compacted to the required density and moisture content as shown below, unless otherwise shown on the plans:

Subgrade Material	Density	Moisture Content
PI ≤ 20	≥ 95% of Max Dry Density	- 2% of Opt. or Greater
PI > 20	≥ 95% of Max Dry Density	≥ Opt. Moisture

The maximum dry density and optimum moisture content shall be determined in accordance with TxDOT Standard Laboratory Test Method Tex-114-E. Tests for in place density shall be made in accordance with TxDOT standard laboratory test method Tex-115-E and within 24 hours after compacting operations are completed. If the material fails to meet the density specified, it shall be re-worked as necessary to obtain the density required.

- 2. Select Fill.** A clean gravel, or gravel approved by the Engineer, conforming to the requirements of article 410.3.B. "Gravel" of Item No.410, "Subgrade Filler" may be used for backfill material from the bottom of the trench to the top of the conduit or as otherwise shown on the plans. The gravel shall be placed in the trench in loose lifts not to exceed 12 inches in depth and lightly tamped to consolidate and seat the mass against conduit and earthen surfaces.

A filter fabric shall be placed on the top and the sides of the gravel backfill (initial backfill) between the trench sides as well as the secondary backfill. The filter fabric shall conform to the requirements of Texas Department of Transportation Material Specification DMS-6200, Type1. Filter fabric shall be considered incidental to construction and no separate payment for filter fabric will be made.

Where conditions permit and with approval of the Engineer, material conforming to Item 200, "Flexible Base" may be used from the top of the gravel filter bed to the top of the box culvert. This backfill material shall be placed in uniform layers not more than 12 inches in depth (loose measurement) and shall be compacted to the required density. Each layer of material, if dry, shall be wetted uniformly to the moisture content required to obtain the specified density and shall be compacted to the required density by means of a mechanical tamper.

Compaction of the Flexible Base shall be such that the density of each layer shall be not

less than 95% of the maximum dry density as determined by TxDOT Standard Laboratory Test Method TEX-113-E, unless otherwise shown on the plans.

- 3. Controlled Low Strength Material (CLSM).** CLSM shall be placed by direct discharge from a mixer truck or other approved method. A minimum of 30 psi at 3 days and maximum strength of 800 psi at 28 days is required. There is no separate pay item for Controlled Low Strength Material, unless shown on the plans as a separate pay item for culvert backfill.
 - 4. Flowable Backfill.** When shown on the plans, backfill the excavation with flowable backfill that conforms to Item 413, "Flowable Backfill" to the elevations shown on the plans. Prevent the structure from being displaced during the placement of the flowable backfill and prevent flowable backfill from entering culverts. There is no separate pay item for Flowable Backfill material, unless shown on the plans as a separate pay item for culvert backfill.
- E. Quality Control.** After each layer of embankment backfill or flexible base is complete, tests as necessary will be made by the Engineer. If the material fails to meet the density specified, the course shall be reworked, as necessary, to obtain the specified compaction.

Should the backfill, due to any reason or cause, lose the required stability, density/moisture, or finish before the next lift is placed, it shall be re-compacted and refinished. Excessive loss of moisture in the backfill shall be prevented by sprinkling or other approved methods.

DIVISION II - BASE & SURFACE COURSES

The following fundamental design criteria shall be utilized by the Design Engineer in developing pavement designs:

1. Soil Borings

Prior to the design of pavements, the Development Engineer shall secure the services of an independent geotechnical laboratory approved by the City Engineer to perform soil borings and to determine the character of the subgrade soils. Sufficient soil borings shall be performed to prepare a soil profile which is representative of the actual soils encountered over the length of the project, and to provide the design engineer with sufficient information for a good engineering design. Fees charged for soil borings shall be paid by the developer. Copies of the laboratory report and the pavement design calculations shall be submitted to the City Engineer for review and approval. If during construction of the project, soil conditions differ substantially from those shown on the soil profile, additional pavement section may be altered accordingly.

2. Subgrade Classification

Strength of subgrade soils shall be determined by one of the three following accepted methods:

- a. Resistance Value - This is a measure of the stability of soils or pavements as determined by a "Stabilometer" which measures the materials resistance to plastic deformation. R-Values are determined by test methods outlined in either AASHTO T190 or ASTM 2844.
- b. CBR - (California Bearing Ratio) This is a measure of the shearing resistance, or load bearing value, of a soil as determined by forcing a three square inch plunger into a cylinder of the soil. CBR values are obtained by test methods outlined in either AASHTO T193 or ASTM 1883.
- c. Triaxial Strength Class: This method classifies soils and base materials by a triaxial shear test in which the specimen is encased in an impervious membrane, subjected to a confining pressure, and then loaded axially to failure. Triaxial Strength Class can be determined by test methods outlined in AASHTO T 212, or Texas Department of Transportation Test Method "Tex- 117-E".

3. Pavement Structure

The design of pavement structures shall be in accordance with the American Association of State Highway and Transportation Officials (AASHTO) Guide for Design of Pavement Structures, 1993 or latest approved edition. The pavement design report shall be prepared and signed by, or under the supervision of, a professional engineer registered in the State of Texas. The following design requirements shall be used for pavement design:

- a. Length of Service Life – Pavement shall be designed for a twenty-year (20-year) service life.
- b. Traffic Load, Reliability and Pavement Structures – The traffic load is cumulative expected 18-Kip equivalent single axle loads (ESAL) for the service life. The following 18-Kip ESAL Reliability Level and Pavement Structure shall be used in the design of streets for each street classification:

Pavement Specifications

Street Classification	18-Kip ESAL	Reliability Level	Minimum Pavement Structure	Maximum Pavement Structure
Primary and Secondary Arterials	3,000,000	R-95	SN = 3.80	SN = 5.76
Collector and Type "B" Streets	2,000,000	R-90	SN = 2.92	SN = 5.08
Type "A" Streets - w/Bus Traffic	1,000,000	R-70	SN = 2.58	SN = 4.20
Type "A" Streets - w/out Bus Traffic	100,000	R-70	SN = 2.02	SN = 3.18

Traffic loads for primary and secondary arterials, collector and local Type "B" streets shall include bus traffic.

- c. Serviceability – The serviceability of a pavement is defined as the pavement’s ride quality and its ability to serve the type of traffic (automobiles and trucks) that use the facility. The initial serviceability index of (p₀) for flexible pavements shall be 4.2 and for rigid pavement shall be 4.5. The minimum terminal serviceability index (P_t) for local streets shall be 2.0 and for collectors and arterials shall be 2.5. A standard deviation (S₀) for flexible pavement shall be 0.45 and for rigid pavement shall be 0.35.
- d. Roadbed Soil – A soil investigation must be performed for the design of pavement structures. The number of borings and locations must be sufficient to accurately determine the stratum along the route. Any existing soil information that is available either from the City or from private sources will be evaluated by the City and, if determined to be applicable and valid, will be allowed in place of new soil tests.

Roadbed soil having a plasticity index (P.I.) greater than twenty (20) shall be treated with lime to reduce the P.I. below twenty (20). Application rate of lime shall be determined by the City Engineer based on laboratory testing. In no case shall the lime be less than fifteen (15) pounds per square yard for six (6) inches of lime treated subgrade. Lime treated subgrade shall be included as a “structural layer” within the pavement design calculations. Proposals for stabilization alternatives in place of the use of lime will be considered for approval by the City Engineer upon submittal of an engineering report verifying adequate stabilization of the highly plastic soil.

Where the roadbed is in a rock excavation a “Structural Layer” within the pavement design calculations may be used that is equivalent to a structural layer for the Lime Stabilized Subgrade, as approved by the City Engineer. If a roadbed Structural Layer is used in the pavement calculation for rock subgrade as approved by the City Engineer, an engineering report must be provided to the City addressing the consistency of the subgrade prior to base placement.

- e. Pavement Layer Material – Alternative pavement materials may be used as approved by the City Engineer where the existing soil or subsurface conditions or the alternative materials provide a level of driveability comparable to the materials otherwise required herein. Where the use of alternative pavement materials are proposed for consideration by the City Engineer, supporting engineering documentation must be submitted to the City. The combination of the following materials will be allowed for pavement structure:
 - 1. Lime treatment for subgrade;
 - 2. Flexible base;
 - 3. Prime coat;
 - 4. Tack coat;
 - 5. Hot mix asphaltic concrete pavement;
 - 6. Asphalt treated base;
 - 7. Reinforced concrete; and
 - 8. Base reinforcement (geogrids).

The City Engineer in consultation with the Infrastructure Compliance Manager in accordance with the standards provided herein must approve the pavement combination.

- f. Minimum Layer Thickness (Compacted) – If the following components are utilized in proposed pavement sections, the minimum thickness for the components shall be as follows, except as modified by the Pavement & Base standards contained herein or as recommended by a geotechnical report whose recommendations are approved by the City Engineer:
 - 1. Hot mix asphaltic concrete pavement shall not be less than one and one-half (1 ½) inches thick for surface course (Type D);

2. Hot mix asphaltic concrete pavement shall not be less than two and one-half (2 ½) inches thick for a leveling-up course (Type B);
3. Asphalt treated base shall not be less than four (4) inches thick;
4. Flexible base shall not be less than six (6) inches thick; and
5. Lime treatment for subgrade shall not be less than six (6) inches thick.

ITEM 200 FLEXIBLE BASE

200.1. DESCRIPTION: Construct a base course for surfacing, pavement, or other base courses composed of crushed stone, and constructed as herein specified in one or more courses in conformance with the typical sections shown on the plans and to the lines and grades as established by the Engineer.

200.2. 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 the TxDOT standard laboratory test procedure Tex-100-E for material definitions.

A. Aggregate. Furnish aggregate of the type and grade shown on the plans and conforming to 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
Aggregate Material Requirements**

Property	Test Method ¹	Grade 1	Grade 2	Grade 3	Grade 4
Master gradation sieve size (% retained)	Tex-110-E				As shown on the plans
2-½ in.		–	0	0	
1-¾ in.		0	0–10	0–10	
¾ in.		10–35	–	–	
¾ in.		30–50	–	–	
No. 4		45–65	45–75	45–75	
No. 40		70–85	60–85	50–85	
Liquid limit, % max. ²	Tex-104-E	35	40	40	As shown on the plans
Plasticity index, max. ²	Tex-106-E	10	12	12	As shown on the plans
Plasticity index, min. ²		As shown on the plans			
Wet ball mill, % max. ³	Tex-116-E	40	45	–	As shown on the plans
Wet ball mill, % max. increase passing the No. 40 sieve ³		20	20	–	

1. TxDOT standard laboratory test procedures

2. Determine plastic index in accordance with Tex-107-E (linear shrinkage) when liquid limit is unattainable as defined in Tex-104-E.

3. ASTM C131 (Grad. A), Los Angeles Abrasion, can be used in lieu of the wet ball mill procedure. The maximum abrasion allowed to the crushed stone is forty (40) when subjected to the Los Angeles Abrasion test.

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 sieve.

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.

2. Material Types. Do not use fillers or binders unless approved by the Engineer. Furnish

the type specified on the plans in accordance with the following.

- a. **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.
 - b. **Type B.** Crushed or uncrushed gravel. Blending of 2 or more sources is allowed. Use of this material must have written approval by the City Engineer prior to selection for bidding or construction.
 - c. **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 TxDOT's standard laboratory test procedure Tex-460-A, Part I. Blending of 2 or more sources is allowed.
 - d. **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 200.2.A.3.b, "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.
 - e. **Type E.** As shown on the plans.
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.
- a. **Limits on Percentage.** When RAP is allowed, do not exceed 20% RAP by weight unless otherwise shown on the plans. The percentage limitations for other recycled materials will be as shown on the plans.
 - b. **Recycled Material (Including Crushed Concrete) Requirements.**
 - (1) **Contractor Furnished Recycled Materials.** 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 TxDOT's 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 TxDOT's standard laboratory test procedure Tex-413-A. For RAP, do not exceed a maximum percent loss from decantation of 5.0% when tested in accordance with TxDOT's standard laboratory test procedure Tex-406-A. Test RAP without removing the asphalt.
 - (2) **City Furnished Required Recycled Materials.** When the City furnishes and requires the use of recycled materials, unless otherwise shown on the plans:
 - City 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% City furnished required recycled

material), the liquid limit, plasticity index, wet ball mill, classification, and compressive strength is waived.

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

(3) City Furnished and Allowed Recycled Materials. When the City 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.

c. Recycled Material Sources. City-owned recycled material is available to the Contractor only when shown on the plans. Return unused City-owned recycled materials to the City 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 City-owned recycled material unless approved by the Engineer.

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

C. Material Sources. Only commercial sources may be used unless otherwise allowed by the City and shown on the plans.

200.3. 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 TxDOT Item 216, "Proof Rolling," when required.

200.4. 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 feet thick. Stockpiles must have a total height between 10 and 16 feet unless otherwise shown on the plans. 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 foot station or designated stockpile site as shown on the plans. Prepare stockpile sites as directed. When delivery is to the 100 foot station, manipulate in accordance with the applicable Items.

A. Preparation of Subgrade or Existing Base. Remove or scarify existing asphalt concrete pavement in accordance with Item 104, "Street Excavation," 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.

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

- B. 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. Maximum lift thickness shall be 10 inches of loose material. 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 City.

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

- C. Compaction.** Compact in courses not to exceed 8 inches compacted depth 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 TxDOT Item 204, "Sprinkling."

Begin rolling longitudinally at the sides and proceed towards the center, overlapping on successive trips by at least $\frac{1}{2}$ the width of the roller unit. On superelevated curves, begin rolling at the low side and progress toward the high side. Offset alternate trips of the roller. Operate rollers at a speed between 2 and 6 mph as directed.

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

- 1. Ordinary Compaction.** Roll with approved compaction equipment as directed. Correct irregularities, depressions, and weak spots immediately by scarifying the areas affected, adding or removing approved material as required, reshaping, and recompacting.
- 2. Density Control.** Compact to at least 95% of the maximum density determined by TxDOT's standard laboratory test procedure Tex-113-E unless otherwise shown on the plans. Determine the moisture content of the material at the beginning and during compaction in accordance with TxDOT's standard laboratory test procedure Tex-103-E.

The Engineer will determine roadway density of completed sections in accordance with TxDOT's standard laboratory test procedure 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 pounds per cubic foot below the specified density.

- D. Finishing.** After completing compaction, clip, skin, or tight-blade the surface with a maintainer or subgrade trimmer to a depth of approximately $\frac{1}{4}$ inch. 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.

In areas where surfacing is to be placed, correct grade deviations greater than $\frac{1}{4}$ inch in 16 feet measured longitudinally or greater than $\frac{1}{4}$ inch over the entire width of the cross-section. Correct by loosening, adding, or removing material. Reshape and recompact in accordance with Section 200.4.C, "Compaction."

E. Curing. Cure the finished section until the moisture content is at least 3 percentage points below and above optimum or as directed before applying the next successive course or prime coat.

ITEM 201

CEMENT TREATED BASE

- 201.1. DESCRIPTION:** *Uniformly mix and compact portland cement, water, and base in the roadway in accordance with these specifications and shape to the lines, grades, and typical sections of the plans. Base materials may be entirely new flexible base, existing pavement materials, or a combination thereof.*
- 201.2. 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 the TxDOT standard laboratory test procedure Tex-100-E for material definitions. Cement shall be placed by slurry method, unless written approval is granted by the Engineer and a safety and containment plan is submitted to the City by the Contractor seven days prior to use.
- A. Cement.** Furnish hydraulic cement that meets the requirements of TxDOT's DMS 4600, "Hydraulic Cement," TxDOT's Hydraulic Cement Quality Monitoring Program (HCQMP), and ASTM C-150 Type I Portland Cement. Sources not on the HCQMP or other sources to be used in combination with an approved source will require approval before use.
 - B. Flexible Base.** When treating entirely new base, furnish material that meets the requirements of Item 200, "Flexible Base," for the type and grade shown on the plans, before the addition of cement. When treating existing flexible base, with or without existing asphalt concrete pavement, the material shall conform to the requirements shown on the plans. Incorporate new base with the existing materials when shown on plans.
 - C. Water.** Furnish water free of industrial waste and other objectionable material.
 - D. Asphalt.** When permitted for curing purposes, furnish asphalt or emulsion that meets the requirements of Item 300, "Asphalts, Oils, and Emulsions," as shown on the plans or directed.
 - E. Mix Design.** The Engineer will determine the target cement content and optimum moisture content to produce a treated mixture that meets the strength requirements shown on the plans. The mix will be designed in accordance with TxDOT standard laboratory test procedure Tex-120-E or will be based on prior experience with the project materials. The Contractor may propose a mix design developed in accordance with TxDOT standard laboratory test procedure Tex-120-E. The Engineer, at their discretion, will use TxDOT standard laboratory test procedure Tex-120-E to verify the Contractor's proposed mix design before acceptance. Reimburse the City for subsequent mix designs or partial designs necessitated by changes in the material or requests by the Contractor, when the City performs these services. When treating existing materials, limit the amount of asphalt concrete pavement to no more than 50% of the mix unless otherwise shown on the plans or directed.
- 201.3. 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 TxDOT Item 216, "Proof Rolling," when required.
- A. Cement Storage Facility.** Store cement in closed, weatherproof containers.
 - B. Cement Slurry Equipment.** Use slurry tanks equipped with agitation devices to slurry cement on the project or other approved location. The Engineer may approve other slurring methods. Provide a pump for agitating the slurry when the distributor truck is not equipped

with an agitator. Equip the distributor truck with an approved sampling device.

C. Pulverization Equipment. Provide pulverization equipment that:

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

201.4. 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.

A. Preparation of Base for Treatment. Prior to treating new base materials, deliver, place, spread, and shape the new material in accordance with Item 200, "Flexible Base" to conform to the typical sections shown on the plans and as directed.

Prior to treating existing pavement, either remove or pulverize existing asphalt concrete pavement in accordance with pertinent Items and the plans or as directed. Shape the material in accordance with applicable bid items to conform to the typical sections shown on the plans and as directed.

When new base is required to be mixed with existing base, deliver, place, and spread the new material in the required amount per station. Manipulate and thoroughly mix the base with existing material to provide a uniform mixture to the specified depth before shaping. Shape the material in accordance with applicable bid items to conform to the typical sections shown on the plans and as directed.

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

B. Pulverization. Pulverize or scarify existing material after shaping so that 100% passes a 2½ inch 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.

C. Application of Cement. Uniformly apply cement using slurry placement unless otherwise approved by the Engineer. Add cement at the percentage determined in Section 201.2.E, "Mix Design." Apply cement only on an area where mixing, compacting, and finishing can be completed during the same working day.

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

1. **Slurry Placement.** Mix the required quantity of cement with water, as approved. Provide slurry free of objectionable materials and with a uniform consistency that can be easily applied. Agitate the slurry continuously. Apply slurry within 2 hours of adding water and when the roadway is at a moisture content drier than optimum. Distribute slurry uniformly by making successive passes over a measured section of the roadway until the specified cement content is reached.
2. **Dry Placement.** Dry placement is not allowed unless approved by the Engineer as described in 201.2, "Materials." If used, before applying cement, bring the prepared

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

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

After mixing, the Engineer will sample the mixture at roadway moisture and test in accordance with TxDOT standard laboratory test procedure Tex-101-E, Part III, to determine compliance with the gradation requirements in Table 1.

Table 1
Gradation Requirements

Sieve Size	Min. % Passing
1- ³ / ₄ in.	100
³ / ₄ in.	85

- E. Compaction.** Compact the mixture in one lift using density control unless otherwise shown on the plans. Complete compaction within 2 hours after the application of cement.

Sprinkle or aerate the treated material in accordance with TxDOT Item 204, "Sprinkling," to adjust the moisture content during compaction so that it is within 2.0 percentage points of optimum as determined by TxDOT standard laboratory test procedure Tex-120-E. Determine the moisture content of the mixture at the beginning and during compaction in accordance with TxDOT standard laboratory test procedure Tex-103-E. Adjust operations as required.

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

Remove areas that lose required stability, compaction, or finish. Replace with cement-treated mixture at the Contractor's expense.

- 1. Ordinary Compaction.** Roll with approved compaction equipment, as directed. Correct irregularities, depressions, and weak spots immediately by scarifying the areas affected, adding or removing treated material as required, reshaping, and recompacting.
- 2. Density Control.** Compact to at least 98% of the maximum density determined in accordance with TxDOT standard laboratory test procedure Tex-120-E. The Engineer will determine roadway density in accordance with TxDOT standard laboratory test procedure Tex-115-E and, at their discretion, will verify strength in accordance with TxDOT standard laboratory test procedure Tex-120-E. Remove material that does not meet density requirements. Remove areas that lose required stability, compaction, or finish. Replace with cement-treated mixture and compact and test in accordance with density control methods.

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 pounds per cubic foot below the specified density.

F. Finishing. Immediately after completing compaction, clip, skin, or tight-blade the surface of the cement treated material with a maintainer or subgrade trimmer to a depth of approximately ¼-inch. Remove loosened material and dispose of it at an approved location. Roll the clipped surface immediately with a pneumatic-tire roller until a smooth surface is attained. Add small increments of water as needed during rolling. Shape and maintain the course and surface in conformity with the typical sections, lines and grades shown on the plans or as directed.

Finish grade of constructed base in accordance with the following grade tolerances:

- 1. Staged Construction.** Grade to within 0.1 foot in the cross-section and 0.1 foot in 16-foot measured longitudinally.
- 2. Turnkey Construction.** Grade to within ½ inch in the cross-section and ½ inch in 16-foot measured longitudinally.

Do not surface patch.

G. Curing. Cure for at least 3 days (24 hours each) by sprinkling in accordance with TxDOT Item 204, "Sprinkling," or by applying an asphalt material at the rate of 0.05 to 0.20 gallon per square yard, as shown on the plans or directed. Maintain the moisture content during curing at no lower than 2 percentage points below optimum. Do not allow equipment on the finished course during curing except as required for sprinkling, unless otherwise approved. Continue curing until placing another course or opening the finished section to traffic.

H. Maintenance. The Contractor shall be required to maintain at his own expense the entire cement treated base within the limits of his contract in good condition satisfactory to the Inspector from the time he first starts work until all work shall have been completed.

Maintenance shall include immediate repairs of any defect that may occur after construction, which work shall be done by the Contractor at his own expense and repeated as often as necessary to keep the area continuously intact. Repairs are to be made in a manner to insure restoration of a uniform surface of good quality cement treated base. Faulty work shall be replaced for the full depth of base. Any low area shall be remedied by replacing the material for the full depth of treatment, rather than adding a thin layer of base material to the completed work.

ITEM 202

PRIME COAT

202.1. DESCRIPTION: *This item shall govern for the application of asphaltic material on the completed base course and/or other areas in accordance with this specification and as directed by the Engineer. Apply blotter material as required.*

202.2. MATERIALS: Provide materials in accordance with the following requirements:

A. Bituminous. Unless the type and grade are shown on the plans, utilize an MC-30 or AE-P asphalt cement in accordance with Item 300, "Asphalts, Oils, and Emulsions" of the Standard Specifications of the Texas Department of Transportation for prime coat. Where Emulsified Asphalts are used, the amount of emulsified asphalt as a percentage by volume of the total mixture shall be within the limits shown on the plans, or shall be of a percentage as directed by the Engineer.

B. Blotter. Unless otherwise shown on the plans or approved, use either base course sweepings obtained from cleaning the base or sand as blotter materials.

202.3. EQUIPMENT: Provide applicable equipment in accordance with this specification or as specified on the plans.

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

1. Transverse Variance Rate. When a transverse variance rate is shown on the plans, confirm that the nozzles outside the wheel paths will output a predetermined percentage more of asphalt material by volume than the nozzles over the wheel paths.

2. Calibration.

a. Transverse Distribution. Furnish a distributor test report, no more than 1 year old, documenting that the variation in output for individual nozzles of the same size does not exceed 10% when tested at the greatest shot width in accordance with Tex-922-K, "Calibrating Asphalt Distribution Equipment," Part III.

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 inch bar height.

When a transverse variance rate is required, 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.

B. Tank Volume. Furnish a volumetric calibration and strap stick for the distributor tank in accordance with Tex-922-K, "Calibrating Asphalt Distribution Equipment," Part I.

Calibrate the distributor within the previous 3 years of the date first used on the project. The Engineer may verify calibration accuracy in accordance with Tex-922-K, "Calibrating Asphalt Distribution Equipment," Part II.

- C. 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.
- D. Broom.** Furnish rotary, self-propelled brooms.
- E. Rollers.** Rollers provided shall meet the requirements for their type as shown in Item 210, "Rollers."
- F. 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.
- G. Digital Measuring Instrument.** Furnish a vehicle with a calibrated digital-measuring instrument accurate to ± 6 ft. per mile.

202.4. CONSTRUCTION:

- A. General.** Apply the mixture when the air temperature is 60°F and above, 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.

- B. Surface Preparation.** Prepare the surface by sweeping or other approved methods. When directed, before applying bituminous material, lightly sprinkle the surface with water to control dust and ensure absorption.

C. Application.

- 1. Bituminous.** The Engineer will select the application temperature within the limits recommended in Item 300, "Asphalts, Oils, and Emulsions." Apply material within 15°F of the selected temperature.

Unless otherwise shown on the plans, prime coat shall be applied at a rate not to exceed 0.20 gallon per square yard of surface. The prime coat shall be applied evenly and smoothly, under a pressure necessary for proper distribution.

When emulsified asphalts are used as prime coat, agitate the water and emulsified asphalt to produce a uniform blend. Evenly distribute, at the rate specified, to locations 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, if necessary.

During the application of prime coat, care shall be taken to prevent splattering of adjacent pavement, curb and gutters or structures. When directed, roll the freshly applied prime coat with a pneumatic-tire roller to ensure penetration.

- 2. Blotter.** Spread blotter material before allowing traffic to use a primed surface. When "Prime Coat & Blotter" is shown on the plans as a bid item, apply blotter material to primed surface at the rate shown in the plans or as directed. When "Prime Coat" is shown on the plans as a bid item, apply blotter to spot locations or as directed to accommodate traffic movement through the work area. Remove blotter material before placing the surface. Dispose of blotter material per applicable state & federal requirements.

ITEM 203 TACK COAT

- 203.1. DESCRIPTION:** *Apply asphaltic material on the completed base course after the prime coat has sufficiently cured, existing pavement, bituminous surface, or in the case of a bridge, on the prepared floor slab in accordance with these specifications and/or as directed by the Engineer.*
- 203.2. MATERIALS:** The asphaltic material used for Tack Coat shall meet the requirements for “Asphalt Cement”, “Cut-Back Asphalt” or “Emulsified Asphalt” in Item No. 300, “Asphalts, Oils and Emulsions” of the Texas Department of Transportation Standard Specifications. The asphaltic material used for Tack Coat shall be the type or grade shown in the referring specification, or on the plans, or as directed/approved by the Engineer.
- 203.3. EQUIPMENT:** Provide equipment that conforms to the requirements of Item 202, “Prime Coat,” Part 3, “Equipment.”
- 203.4. CONSTRUCTION:** Before the tack coat is applied, the surface shall be cleaned thoroughly with a vacuum sweeper to the satisfaction of the Engineer. The asphaltic material shall be applied on the clean surface by an approved type of self-propelled pressure distributor evenly and smoothly under a pressure necessary for proper distribution.

The tack coat shall be applied at the rate specified by the referring specification or on the plans. Unless otherwise stated or allowed by the Engineer the application rate shall not exceed 0.10 gallon per square yard of surface.

Where the pavement mixture will adhere to the surface on which it is to be placed without the use of a tack coat, the tack coat may be eliminated by the Engineer. All contact surfaces of curbs and structures and all joints shall be painted with a thin uniform coat of the asphaltic material used for tack coat. During the application of tack coat, care shall be taken to prevent splattering of adjacent pavement, curb and gutters or structures.

ITEM 204

SURFACE TREATMENTS

204.1. DESCRIPTION: *Construct a surface treatment composed of a single or double application of asphalt material, each covered with aggregate, constructed on existing pavements or on the prepared base course or surface in accordance with these specifications. This item shall also govern for the furnishing and placing of aggregates. Quantities for the different types of surfaces and materials will be shown on the plans.*

204.2. MATERIALS: All materials shall be of the type and grade as shown on the plans and shall conform to the pertinent material requirements of the following:

A. Asphaltic Cement. TxDOT Item 300, "Asphalts, Oils, and Emulsions."

B. Aggregates. TxDOT Item 302, "Aggregates for Surface Treatments."

204.3. EQUIPMENT: Provide applicable equipment in accordance with this specification or as specified on the plans.

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

1. Transverse Variance Rate. When a transverse variance rate is shown on the plans, ensure that the nozzles outside the wheel paths will output a predetermined percentage more of asphalt material by volume than the nozzles over the wheel paths.

2. Calibration.

a. Transverse Distribution. Furnish a distributor test report, no more than 1 year old, documenting that the variation in output for individual nozzles of the same size does not exceed 10% when tested at the greatest shot width in accordance with Tex-922-K, "Calibrating Asphalt Distribution Equipment," Part III.

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-inch bar height.

When a transverse variance rate is required, 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.

b. Tank Volume. Furnish a volumetric calibration and strap stick for the distributor tank in accordance with Tex-922-K, "Calibrating Asphalt Distribution Equipment," Part I.

Calibrate the distributor within the previous 3 years of the date first used on the project. The Engineer may verify calibration accuracy in accordance with Tex-922-K, "Calibrating Asphalt Distribution Equipment," Part II.

3. 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.

- B. Aggregate Spreader.** Use a continuous-feed, self-propelled spreader to apply aggregate uniformly at the specified rate or as directed.
- C. Broom.** Furnish rotary, self-propelled brooms.
- D. Aggregate Haul Trucks.** Unless otherwise authorized, 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.
- E. Rollers.** Unless otherwise shown on the plans, rollers provided shall meet the requirements for “Pneumatic Tire” as shown in Item 210, “Rollers.”
- F. 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.

- G. Digital Measuring Instrument.** Furnish a vehicle with a calibrated digital-measuring instrument accurate to ± 6 feet per mile.

204.4. CONSTRUCTION:

- A. General.** Asphalt and aggregate rates shown on the plans are for estimating purposes only. The Engineer will adjust the rates for the existing conditions.
- B. Weather.** 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.

- 1. Standard Temperature Limitations.** Apply surface treatment when air temperature is above 50°F and rising. Do not apply surface treatment when air temperature is 60°F and falling. In all cases, do not apply surface treatment when surface temperature is below 60°F.
 - 2. Polymer-Modified Asphalt Cement Temperature Limitations.** When using materials described in TxDOT Item 300, Section 2.B, “Polymer Modified Asphalt Cement,” apply surface treatment when air temperature is above 70°F rising. Do not apply surface treatment when air temperature is 80°F and falling. In all cases, do not apply surface treatment when surface temperature is below 70°F.
 - 3. Asphalt Material Designed for Winter Use.** When winter asphalt application is allowed, the Engineer will approve the air and surface temperature for asphalt material application. Apply surface treatment at air and surface temperatures as directed.
- C. 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.

Building paper shall be placed over all manholes, valve boxes, grates, etc., so as to protect the surfaces from asphaltic materials. Asphaltic materials shall not be placed, lapped, or splashed onto adjacent structures.

- D. Rock Land and Shot.**

1. Definitions.

- a. A “rock land” is the area covered at the aggregate rate directed with 1 truckload of aggregate.
 - b. A “shot” is the area covered by 1 distributor load of asphalt material.
- 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.

E. Asphalt Placement.

- 1. General.** The maximum shot width is the width of the current transverse distribution test required under Section 204.3.A.2.a, “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.

In those areas where the asphalt distributor is not accessible, hand spraying may be permitted as directed by the Engineer.

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

- 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
- haul trucks are in place behind the spreader box.

- 3. Non-Uniform Applications.** 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 non-uniform application. If the cause is high or low emulsion viscosity, replace emulsion with material that corrects the problem.

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

- non-uniformity of application continues after corrective action;
- on 3 consecutive shots, application rate differs by more than 0.03 gallons per square yard from the rate directed; or

- any shot differs by more than 0.05 gallons per square yard from the rate directed. The Engineer or City will approve the test strip location. The Engineer may require additional test strips until surface treatment application meets specification requirements.

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

G. 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.

H. 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.

I. Brooming. After rolling, sweep as soon as aggregate has sufficiently bonded to remove excess.

After rolling of the finished surface is completed, all parkways, private property, and driveways adjacent to the work shall be cleared of any surplus aggregate by the Contractor by sweeping.

Until the work has been accepted, additional sweeping shall be required as often as necessary so that loose aggregate does not present a hazard to traffic.

J. Final Acceptance. Maintain surface treatment until the Engineer accepts the work. Repair any surface failures.

K. Two-Course Surface Treatments. It is the intent of this specification that the application of asphalt and aggregate for multiple courses be applied within the same day, or immediately thereafter, and prior to opening the roadway to traffic.

The asphaltic material for each course of the surface treatment shall be applied and covered with aggregate in the same manner specified for the first application. Each surface shall then be broomed or raked as required by the Engineer and thoroughly rolled as specified for the first course. Asphaltic material and aggregate for each course shall be applied at the rates directed by the Engineer or as shown on the plans.

The Contractor shall be responsible for the maintenance of each course until covered by the succeeding courses or until the work is accepted by the Engineer. All holes or failures in the surface shall be repaired by use of additional asphalt and aggregate. All fat or bleeding surfaces shall be covered with approved cover material in such a manner that the asphaltic material will not adhere to or be picked up by the wheels of vehicles.

ITEM 205

HOT MIX ASPHALTIC CONCRETE PAVEMENT

- 205.1. DESCRIPTION:** *Construct a leveling-up course, a surface course or any combination of these courses as shown on the plans, each to be composed of a compacted mixture of mineral aggregate and asphaltic material. The pavement shall be constructed on the newly constructed subgrade or base course, existing pavement, bituminous surface or in the case of bridges, on the prepared floor slab, as herein specified and in accordance with the details shown on the plans.*
- 205.2. MATERIALS:** Materials used in Hot Mix Asphaltic Concrete Pavement shall meet the requirements as set forth herein. If shown on the plans, materials may also meet the requirements as described in Item 340, “Dense-Graded Hot-Mix Asphalt (Method)” or Item 341, “Dense-Graded Hot-Mix Asphalt (QC/QA)” of the Texas Department of Transportation Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges.

Unless otherwise shown on the plans, provide aggregates that meet the aggregate quality requirements of TxDOT’s Bituminous Rated Source Quality Catalog (BRSQC). Unapproved sources may be used if accepted by the Engineer and approved prior to use.

Furnish aggregates from sources that conform to the requirements shown in Table 1 herein, and as specified in this Section, unless otherwise shown on the plans. Provide aggregate stockpiles that meet the definition in this Section for either a coarse aggregate or fine aggregate. When reclaimed asphalt pavement (RAP) is used, provide RAP stockpiles in accordance with this Section. Aggregate from RAP is not required to meet Table 1 requirements unless otherwise shown on the plans.

Document all test results on a mixture design report and submit to the Engineer for approval. The Engineer may perform tests on independent or split samples to verify Contractor mix design 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 TxDOT standard laboratory test procedure Tex-200-F, Part II. Do not add material to an approved stockpile from other sources, unless otherwise approved by the Engineer.

Unless otherwise shown on the plans, reclaimed asphalt pavement (RAP) may be used in asphalt pavement maintenance or rehabilitation applications and shall be limited to a maximum of 20% RAP for surface or wearing courses and 30% RAP for courses below the surface or wearing course. Higher percentages of RAP may be used if requested in writing and approved by the Engineer prior to use.

- A. Coarse Aggregate.** Coarse aggregate stockpiles must have no more than 20% passing the #8 sieve. Provide aggregates with a surface aggregate classification (SAC) as shown below:

<u>Street Classification</u>	<u>Min. Surface Aggregate Classification</u>
Primary and Secondary Arterials	A
Collector and Local Type B Streets	B
Local Type A Street With Bus Traffic	B
Local Type A Street Without Bus Traffic	C

SAC requirements apply only to aggregates used on the surface of travel lanes, unless otherwise shown on the plans. Blending aggregates to meet SAC criteria is allowable. Class B aggregate meeting all other requirements in Table 1 may be blended with a Class A aggregate in order to meet requirements for Class A materials. When blending Class A and B aggregates to meet a Class A requirement, ensure that at least 50% by weight of the material retained on the No. 4 sieve comes from the Class A aggregate source. Blend by volume if the bulk specific gravities of the Class A and B aggregates differ by more than 0.300. When

blending, do not use Class C or D aggregates. For blending purposes, coarse aggregate from RAP will be considered as Class B aggregate.

- B. Reclaimed Asphalt Pavement (RAP).** RAP is defined as a salvaged, pulverized, broken or crushed asphalt pavement. The RAP to be used in the mix shall be crushed or broken to the extent that 100% will pass the two inch sieve.

The stockpiled RAP shall not be contaminated by dirt or other objectionable materials. Unless otherwise shown on the plans, stockpiled, crushed RAP shall have a decantation of 5% or less and a plasticity index of eight (8) or less, when tested in accordance with TxDOT standard laboratory test procedures Tex-406-A, Part I, and Tex-106-E, respectively. This requirement applies to stockpiles from which the asphalt has not been removed by extraction. When RAP is used, determine asphalt content and gradation for mixture design purposes.

- C. Fine Aggregate.** Fine aggregates may consist of manufactured sands, screenings and field sands. Supply fine aggregates that are free from organic impurities. Field sands and other uncrushed aggregates shall be limited to 15% of the total aggregate.

If 10% or more of the fine aggregate stockpile is retained on the No. 4 sieve, test the stockpile and verify that it meets the requirements in Table 1 for coarse aggregate angularity (TxDOT standard laboratory test procedure Tex-460-A) and flat and elongated particles (TxDOT standard laboratory test procedure Tex-280-F).

- D. Asphalt Binder.** Unless shown on the plans, provide the type and grade of performance-graded asphalt binder in accordance with TxDOT Item 300.2.J. "Performance-Graded Binders" and as specified below:

Street Classification	Minimum PG Asphalt Cement Grade		
	Surface Courses	Binder & Level Up Courses	Base Courses
Primary and Secondary Arterials	PG 76-22	PG 70-22	PG 64-22
Collector and Local Type B Streets	PG 70-22		
Local Type A Street With Bus Traffic		PG 64-22	
Local Type A Street Without Bus Traffic	PG 64-22		

- E. Mineral Filler.** Mineral filler consists of finely divided mineral matter such as agricultural lime, crusher fines, hydrated lime, cement, or fly ash. Mineral filler is allowed unless otherwise shown on the plans. Do not use more than 2% hydrated lime or cement, unless otherwise shown on the plans. The plans may require or disallow specific mineral fillers. When used, provide mineral filler that:

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

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

- G. Tack Coat.** Unless otherwise shown on the plans or approved, furnish CSS-1H, SS-1H, or a PG binder with a minimum high-temperature grade of PG 58 for tack coat binder and in

accordance with Item 203, “Tack Coat.” Do not dilute emulsified asphalts at the terminal, in the field, or at any other location before use.

H. Additives. When shown on the plans, use the type and rate of additive specified. Other additives that facilitate mixing or improve the quality of the mixture may be allowed when approved. If lime or a liquid antistripping agent is used, add in accordance with TxDOT Item 301, “Asphalt Anti-stripping 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.

**Table 1
Aggregate Quality Requirements**

Property	TxDOT Standard Laboratory Test Procedure	Surface Courses	Binder, Level Up, & Base Courses
Coarse Aggregate			
Deleterious Material, %, max	Tex-217-F, Part I	1.0	1.5
Decantation, %, max	Tex-217-F, Part II	1.5	1.5
Micro-Deval Abrasion, %, max	Tex-461-A	Screening Only	Screening Only
Los Angeles Abrasion, %, max	Tex-410-A	35	40
Magnesium Sulfate Soundness, 5 cycles, %, max	Tex-411-A	25	30
Coarse Aggregate Angularity, 2 crushed faces, %, min	Tex-460-A, Part I	95 ¹	85 ¹
Flat and Elongated Particles @ 5:1, %, max	Tex-280-F	10	10
Fine Aggregate			
Linear Shrinkage, %, max	Tex-107-E	3	3
Combined Aggregate²			
Sand Equivalent, %, min	Tex-203-F	45	45

Note 1: Applies to Gravel Only

Note 2: Aggregate without mineral filler, RAP, or additives combined as used in the job-mixed formula (JMF)

**Table 2
Gradation Requirements for Fine Aggregates**

Sieve Size, in	% Passing by Weight or Volume
3/8	100
#8	70 – 100
#200	0 – 30

**Table 3
Gradation Requirements for Mineral Filler**

Sieve Size, in	% Passing by Weight or Volume
#8	100
#200	55 – 100

205.3. EQUIPMENT: All equipment for the handling of all materials, mixing, placing and compacting of the mixture shall be maintained in good repair and operating condition and subject to the approval of the Engineer. Any equipment found to be defective and potentially having a negative effect on the quality of the paving mixture or ride quality will not be allowed.

A. Spreading and Finishing Machine. The spreading and finishing machine shall be approved by the Engineer and shall meet the requirements indicated below.

1. Screed Unit. The spreading and finishing machine shall be equipped with a heated compacting screed. It shall produce a finished surface meeting the requirements of the typical cross sections and the surface test.

Extensions added to the screed shall be provided with the same compacting action and

heating capability as the main screed unit, except for use on variable depth tapered areas and/or as approved by the Engineer.

The spreading and finishing machine shall be equipped with an approved automatic dual longitudinal screed control system and automatic transverse screed control system. The longitudinal controls shall be capable of operating from any longitudinal grade reference including a stringline, ski, mobile stringline, or matching shoe.

The Contractor shall furnish all equipment required for grade reference. It shall be maintained in good operating condition by personnel trained in the use of this type of equipment.

The grade reference used by the Contractor may be of any type approved by the Engineer. The contractor shall set the grade reference to have sufficient support so that the maximum deflection shall not exceed 1/16 inch between supports.

2. **Tractor Unit.** The tractor unit shall be equipped with a hydraulic hitch sufficient in design and capacity to maintain contact between the rear wheels of the hauling equipment and the pusher rollers of the finishing machine while the mixture is being unloaded.

No portion of the weight of hauling equipment, other than the connection, shall be supported by the asphalt paver. No vibrations or other motions of the loading equipment, which could have a detrimental effect on the riding quality of the completed pavement, shall be transmitted to the paver.

The use of any vehicle which requires dumping directly into the finishing machine and which the finishing machine cannot push or propel to obtain the desired lines and grades without resorting to hand finishing will not be allowed.

- B. **Material Transfer Equipment.** Equipment to transfer mixture from the hauling units or the roadbed to the spreading and finishing machine will be allowed unless otherwise shown on the plans. A specific type of material transfer equipment shall be required when shown on the plans.
- C. **Motor Grader.** The motor grader, when used, shall meet the requirements as shown in Item 220, "Blading."
- D. **Rollers.** Rollers provided shall meet the requirements for their type as shown in Item 210, "Rolling."

205.4. CONSTRUCTION: It shall be the responsibility of the Contractor to design, produce, transport, place and compact the specified paving mixture in accordance with the requirements herein. The Engineer will perform verification testing as needed. Provide quality control (QC) testing as needed to meet the requirements of this Item. Provide a certified Level I-A specialist at the plant during production hours. Provide a certified Level I-B specialist to conduct placement tests.

- A. **Quality Control Plan (QCP).** Unless otherwise shown on the plans, develop and follow a QCP. Obtain approval from the Engineer for changes to the QCP made during the project. The Engineer may suspend operations if the Contractor fails to comply with the QCP.

Submit a written QCP to the Engineer and receive the Engineer's approval of the QCP before beginning production. Include the following items in the QCP.

1. **Project Personnel.** Provide:

- a. a list of individuals that will conduct tests as well their associated certifications (i.e.

Level IA, IB, and II certifications), including when certifications will expire for each individual; and

- b. a list of individuals responsible for QC with authority to take corrective action and the contact information for each individual listed.

2. Material Delivery and Storage. Provide:

- a. the sequence of material processing, delivery, and minimum quantities to assure continuous plant operations;
- b. aggregate stockpiling procedures to avoid contamination and segregation;
- c. frequency, type, and timing of aggregate stockpile testing to assure conformance of material requirements before mixture production; and
- d. procedure for monitoring the quality and variability of asphalt binder.

3. Production. Detail:

- a. loader operation procedures to avoid contamination in cold bins;
- b. procedures for calibrating and controlling cold feeds;
- c. procedures to eliminate debris or oversized material;
- d. procedures for adding and verifying rates of each applicable mixture component (e.g., aggregate, asphalt binder, RAP, lime, liquid antistripping);
- e. procedures for reporting job control and acceptance test results; and
- f. procedures to avoid segregation and drain-down in the silo.

4. Loading and Transporting. Provide:

- a. the type and application method for release agents; and
- b. truck loading procedures to avoid segregation.

5. Placement and Compaction. Provide:

- a. the proposed agenda for mandatory pre-paving meeting including date and location;
- b. the type and application method for release agents in the paver and on rollers, shovels, lutes, and other utensils;
- c. procedures for the transfer of mixture into the paver while avoiding segregation and preventing material spillage;
- d. the process to balance production, delivery, paving, and compaction to achieve continuous placement operations;
- e. the paver operations (e.g., operation of wings, height of mixture in auger chamber) to avoid physical and thermal segregation and other surface irregularities; and
- f. procedures to construct quality longitudinal and transverse joints.

B. Mixture Design. Use a Level II specialist certified by a TxDOT-approved hot-mix asphalt certification program to develop the mixture design. Have the Level II specialist sign the design documents. Unless otherwise shown on the plans, use the typical weight design example given in TxDOT standard laboratory test procedure Tex-204-F, Part I or Part III, to design a mixture meeting the requirements listed in Tables 1 through 5. At the request of the Engineer, furnish representative samples of all materials used in the mixture design for verification. If the design cannot be verified by the Engineer, furnish another mixture design.

The Contractor may submit a new mixture design at anytime during the project. The Engineer will approve all mixture designs before the Contractor can begin production.

Provide the Engineer with a mixture design report that includes the following items:

- the combined aggregate gradation, source, specific gravity, and percent of each material used;
- results of all applicable tests;
- the mixing and molding temperatures;
- all applicable correlation and correction factors;
- the signature of the Level II person or persons who performed the design;
- the date the mixture design was performed; and
- a unique identification number for the mixture design.

The Hamburg Wheel Test is not required, unless otherwise shown on the plans. When required through plan note, the minimum number of passes shown in Table 6 shall be met, unless otherwise approved by the Engineer. The contractor will be responsible for submitting the results of the Hamburg Wheel test to the Engineer with the other mixture design data. Use an approved laboratory to perform the Hamburg Wheel test. The TxDOT Construction Division maintains a list of approved laboratories that may be referenced. Hamburg Wheel Testing will not be performed or required for any Type “F” mixtures.

Table 4
Master Gradation Bands (% Passing by Weight or Volume) and Volumetric Properties

Sieve Size	A Coarse Base	B Fine Base	C Coarse Surface	D Fine Surface	F Fine Mixture
1-1/2"	98.0–100.0	–	–	–	–
1"	78.0–94.0	98.0–100.0	–	–	–
3/4"	64.0–85.0	84.0–98.0	95.0–100.0	–	–
1/2"	50.0–70.0	–	–	98.0–100.0	–
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	35.0–50.0
#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 Voids in the Mineral Aggregate (VMA), % minimum					
	12.0	13.0	14.0	15.0	16.0
Plant-Produced Voids in the Mineral Aggregate (VMA), % minimum					
	11.0	12.0	13.0	14.0	15.0

**Table 5
Laboratory Mixture Design Properties**

Property	TxDOT Standard Laboratory Test Procedure	Required	
Target laboratory-molded density, %	Tex-207-F	96.5	Base, Binder, and Level Up Courses
		Surface or Wearing Courses	
		96.5	Primary and Secondary Arterials
		97.0	Collectors, Local Type B Streets, and Local Type A Street With Bus Traffic
		97.5	Local Type A Street Without Bus Traffic
Boil test ¹	Tex-530-C	-	

1. Used to establish baseline for comparison to production results. May be waived when approved.

**Table 6
Hamburg Wheel Test Requirements¹**

High-Temperature Binder Grade	Minimum # of Passes ² @ 0.5" Rut Depth, Tested @ 122°F
PG 64 or lower	5,000
PG 70	10,000
PG 76 or higher	20,000

1. Tested in accordance with Tex-242-F.
2. May be decreased if shown on the plans.

C. Job-Mix Formula. The laboratory mixture design shall be submitted to the Engineer for approval prior to production and placement. The submittal shall provide the laboratory designed mixture target properties and data that demonstrate the contractor's ability to produce the mixture within the tolerances specified in Table 7 herein either through a trial batch or by submittal of previous production data from a City or TxDOT project.

Once approved, the contractor may begin production and placement of the approved JMF. Results from Lot 1 of the JMF may be used to modify the optimum mixture properties as long as the tested properties are within the tolerances specified in Table 7 herein. Further adjustments to the JMF may be allowed by the Engineer during production and placement, if warranted. JMF adjustment requests must be made in writing to the Engineer and the mixture must conform to the master gradation limits for the mixture type and be within the operational limits of Table 7 noted above for the initial JMF approved by the Engineer.

**Table 7
Operational Tolerances**

Description	Test Method	Allowable Difference from Current JMF Target
Individual % Retained for #8 Sieve or Larger	Tex-200-F or Tex-236-F	±5.0 ¹
Individual % Retained for Sieves Smaller than #8 and Larger than #200		±3.0 ¹
% Passing the #200 Sieve		±2.0 ¹
Asphalt Content, %	Tex-236-F	±0.3 ²
Laboratory-Molded Density, %	Tex-207-F	±1.0
VMA, % minimum		Note 3

Note 1: When within these tolerances, mixture production gradations may fall outside the master grading limits; however, the % passing the #200 sieve will be considered out of tolerance when outside the master grading limits.

Note 2: Tolerance between Laboratory Mix and Plant Trial Batch may exceed ±0.3.

Note 3: Test and verify that Table 4 requirements are met.

- D. Production.** Do not heat the asphalt binder above the temperatures specified in TxDOT Item 300, "Asphalts, Oils, and Emulsions," or outside the manufacturer's recommended values. Do not store an asphaltic mixture for a period long enough to affect the quality of the mixture, nor in any case longer than 12 hr.

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. The Engineer will not pay for, or allow placement of, any mixture produced at more than 350°F. Control the mixing time and temperature so that moisture is removed from the mixture before discharging from the plant. If requested, determine the moisture content by oven-drying in accordance with TxDOT standard laboratory test procedure Tex-212-F, Part II, and verify that the mixture contains no more than 0.2% of moisture by weight. Obtain the sample immediately after discharging the mixture into the truck, and perform the test promptly.

Perform a new trial batch when the plant or plant location is changed. The Engineer may suspend production for noncompliance with this Item. Take corrective action and obtain approval to proceed after any production suspension for noncompliance.

- E. Tack Coat.** The surface upon which the tack coat is to be placed shall be cleaned thoroughly to the satisfaction of the Inspector. The surface shall be given a uniform application of tack coat using asphaltic materials of this specification. Unless otherwise shown on the plans, tack coat shall be applied with an approved sprayer at a rate directed by the Engineer between 0.04 and 0.10 gallon residual asphalt per square yard of surface.

- F. Transporting Asphaltic Concrete.** The asphaltic mixture shall be hauled to the work site in vehicles previously cleaned of all foreign material and with beds that do not discharge or lose materials during the haul. Trucks that do not meet the satisfaction of the Engineer or Inspector will not be allowed to deliver materials to City projects. The dispatching of the vehicles shall be arranged so that all material is delivered, placed, and rolled during daylight hours unless otherwise shown on the plans. In cool weather, or for long hauls, covering and insulating of the truck bodies may be required. If necessary, to prevent the mixture from adhering to the inside of the truck body, the inside of the truck may be given a light coating of release agent satisfactory to the Engineer.

G. Placement.

- 1. Weather Conditions.** Place mixture, when placed with a spreading and finishing machine, or the tack coat when the roadway surface temperature is 60°F or higher unless otherwise approved. Measure the roadway surface temperature with a handheld infrared thermometer. Place mixtures only when weather conditions and moisture conditions of the roadway surface are suitable in the opinion of the Engineer.

The asphaltic mixture, when placed with a motor grader, shall not be placed when the surface temperature is below 65°F and is falling, but may be placed when the surface temperature is above 55°F and is rising. The maximum depth of asphalt mixture placed with a motor grader will not exceed 5 inches of compacted material.

Mat thicknesses of 1-½ inches and less shall not be placed when the temperature of the surface on which the mat is to be placed is below 60°F.

It is further provided that the tack coat or asphaltic mixture shall be placed only when the humidity, general weather conditions, temperature and moisture condition of the base are suitable.

- 2. Placement Temperature.** If, after being discharged from the mixer and prior to placing,

the temperature of the asphaltic mixture falls below 200°F, all or any part of the load may be rejected and payment will not be made for the rejected material.

3. **Placement Operations.** Placement and laydown operations shall be in conformance with this section and Section 205.4.H. - "Quality Control and Acceptance."

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.

The asphaltic mixture shall be dumped and spread on the approved prepared surface with the spreading and finishing machine. Place the mixture to meet the typical section requirements and produce a smooth, finished surface with a uniform appearance and texture. In addition, the placing of the asphaltic mixture shall be completed without tearing, shoving, gouging or segregating the mixture and without producing streaks in the mat.

Unloading into the finishing machine shall be controlled so that bouncing or jarring the spreading and finishing machine shall not occur and the required lines and grades shall be obtained without resorting to hand finishing.

When approved by the Engineer, level-up courses may be spread with a motor grader.

Construction joints of successive courses of asphaltic material shall be offset at least 6 inches. Construction joints on surface courses shall coincide with lane lines, or as directed by the Engineer.

The spreading and finishing machine shall be operated at a uniform forward speed consistent with the plant production rate, hauling capability, and roller train capacity to result in a continuous operation. The speed shall be slow enough that stopping between trucks is not ordinarily required. If, in the opinion of the Inspector, sporadic delivery of material is adversely affecting the mat, the Inspector may require paving operations to cease until acceptable methods are provided to minimize starting and stopping of the paver.

The hopper flow gates of the spreading and finishing machine shall be adjusted to provide an adequate and consistent flow of material. These shall result in enough material being delivered to the augers so that they are operating approximately 85 percent of the time or more. The augers shall provide means to supply adequate flow of material to the center of the paver. Augers shall supply an adequate flow of material for the full width of the mat, as approved by the Engineer. Augers should be kept approximately one-half to three-quarters full of mixture at all times during the paving operation.

When the asphaltic mixture is placed in a narrow strip along the edge of an existing pavement, or used to level up small areas of an existing pavement, or placed in small irregular areas where the use of a finishing machine is not practical, the finishing machine may be eliminated when authorized by the Engineer.

Adjacent to flush curbs, gutters and structures, the surface shall be finished uniformly high so that when compacted, it will be slightly above the edge of the curb or structure.

If a pattern of surface irregularities or segregation is detected, the Contractor shall make an investigation into the causes and immediately take the necessary action. With the approval of the Inspector, placement may continue for no more than one full production day from the time the Contractor is first notified and while corrective actions are being taken. If the problem still exists after that time, paving shall cease until the Contractor

further investigates the causes and the Engineer approves further corrective action to be taken.

Place mixture within the compacted lift thickness shown in Table 8, unless otherwise shown on the plans or allowed.

Use the guidelines in Table 9 to establish the temperature of mixture delivered to the paver.

**Table 8
Compacted Lift Thickness and Required Core Height**

Mixture Type	Compacted Lift Thickness		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

**Table 9
Suggested Minimum Mixture Placement Temperature**

High-Temperature Binder Grade	Minimum Placement Temperature (Before Entering Paver)
PG 64 or lower	260°F
PG 70	270°F
PG 76	280°F
PG 82 or higher	290°F

4. **Compaction.** The pavement shall be compacted thoroughly and uniformly with the necessary rollers to obtain the compaction and cross section of the finished paving mixture meeting the requirements of the plans and specifications.

The edges of the pavement along curbs, headers and similar structures, and all places not accessible to the roller, or in such positions as will not allow thorough compaction with the rollers, shall be thoroughly compacted with lightly oiled tamps.

Rolling with a trench roller will be required on widened areas, in trenches and other limited areas where satisfactory compaction cannot be obtained with the approved rollers.

- a. **In-Place Compaction Control.** Use density control unless ordinary compaction control is specified on the plans. Use the control strip method given in Tex-207-F, Part IV, to establish the rolling pattern for density controlled areas.

Where specific density or air void requirements are waived, furnish and operate compaction equipment as approved.

Do not use pneumatic-tire rollers if excessive pickup of fines by roller tires occurs. Unless otherwise directed, use only water or an approved release agent on rollers, tamps, and other compaction equipment. Keep diesel, gasoline, oil, grease, and other foreign matter off the mixture.

When rolling with the three-wheel, tandem or vibratory rollers, it is recommended that rolling start by first rolling the joint with the adjacent pavement and then continue by rolling longitudinally at the sides and proceed toward the center of the pavement, overlapping on successive trips by at least 1 foot. Alternate trips of the roller should be slightly different in length. On super-elevated curves, rolling should

begin at the low side and progress toward the high side.

When rolling with vibratory steel-wheel rollers, equipment operation shall be in accordance with Item 210, "Rolling", and the manufacturer's recommendations, unless otherwise directed by the Engineer. Vibratory rollers shall not be left vibrating while not rolling or when changing directions. In addition, vibratory rollers shall not be allowed in the vibrating mode on mats with a plan depth of less than 1-½ inches, unless approved by the Engineer.

The motion of the rollers shall be slow enough to avoid other than usual initial displacement of the mixture. If any displacement occurs, it shall be corrected to the satisfaction of the Inspector. Ensure pavement is fully compacted before allowing rollers to stand on the pavement.

(1) Ordinary Compaction Control. One three-wheel roller, one pneumatic-tire roller, and one tandem roller shall be furnished for each compaction operation except as provided below or approved by the Engineer. The use of a tandem roller may be waived by the Engineer when the surface is already adequately smooth and further steel-wheel rolling is shown to be ineffective. With approval of the Engineer, the Contractor may substitute a vibratory roller for the three-wheel roller and/or the tandem roller. Use of at least one pneumatic-tire roller is required unless approved by the Engineer. Additional or heavier rollers shall be furnished if required by the Engineer.

Rolling patterns shall be established by the Contractor to achieve the maximum compaction. The selected rolling pattern shall be followed unless changes in the mixture or placement conditions occur which affect compaction. When changes in the mixture or placement conditions occur, a new rolling pattern shall be established.

(2) Density Compaction Control. Place and compact asphaltic concrete materials in accordance with the method specified in Section 205.4.H, "Quality Control and Acceptance."

5. **Compaction Cessation Temperature.** Regardless of the method required for in-place compaction control, all rolling for compaction shall be completed before the mixture temperature drops below 175°F.
6. **Opening to Traffic.** Allow the compacted pavement to cool to 160°F or lower before opening to traffic unless otherwise directed. When directed, sprinkle the finished mat with water or limewater to expedite opening the roadway to traffic.

If the surface ravel, flushes, ruts or deteriorates in any manner prior to final acceptance of the work, it will be the Contractor's responsibility to correct this condition at their expense, to the satisfaction of the Inspector and in conformance with the requirements of this specification.

H. Quality Control and Acceptance. Control and acceptance of hot mixed asphaltic concrete pavement shall be followed as specified herein or as directed on the plans. The contractor shall conduct production and placement operations in accordance with the method specified. All testing will be conducted in accordance with the testing methods shown in Table 10.

Table 10
Acceptable Production and Placement Testing Methods

Description	Test Method
Gradation including % passing the #200 sieve	Tex-200-F or Tex-236-F
Laboratory-molded density	Tex-207-F
VMA	
Laboratory-molded bulk specific gravity	
In-Place air voids	
Segregation (density profile)	Tex-207-F, Part V
Longitudinal joint density	Tex-207-F, Part VII
Moisture content	Tex-212-F, Part II
Theoretical maximum specific (Rice) gravity	Tex-227-F
Asphalt content	Tex-236-F
Hamburg Wheel test	Tex-242-F
Thermal profile	Tex-244-F
Asphalt binder sampling and testing ¹	Tex-500-C
Boil test ¹	Tex-530-C

1. The Engineer may waive the sampling and testing requirements at their discretion.

- 1. Production Sampling and Testing.** For a given project, sample asphaltic concrete materials at the production facility every 500 tons for each mixture type supplied or as directed by the Engineer. Unless otherwise shown on the plans, a production facility that supplies the same mixture to multiple City projects on the same day will not be required to sample and test at the required frequency for every project. A single test report may be used on two or more projects to represent the quality of the mixture for that day's production.

During production, do not exceed the operational tolerances in Table 7. Stop production if testing indicates tolerances are exceeded on:

- 3 consecutive tests on any individual sieve,
- 4 consecutive tests on any of the sieves, or
- 2 consecutive tests on asphalt content.

Suspend production and shipment of mixture if the asphalt content deviates from the current JMF by more than 0.5% for any test.

Begin production only when test results or other information indicate, to the satisfaction of the Engineer, that the next mixture produced will be within Table 7 tolerances.

The Contractor shall perform a Hamburg Wheel test at the direction of the Engineer at any time during production, including when the boil test indicates a change in quality from the materials submitted for the initial JMF. If the production sample fails the Hamburg Wheel test criteria in Table 6, suspend production until further Hamburg Wheel tests meet the specified values. The Engineer may require up to the entire subplot of any mixture failing the Hamburg Wheel test to be removed and replaced at the Contractor's expense.

If the Hamburg Wheel test results in a "remove and replace" condition, the Contractor may request that the Engineer confirm the results by retesting the failing material. An Independent laboratory retained by the Engineer will perform the Hamburg Wheel tests and determine the final disposition of the material in question based on the initial test results.

2. Placement Sampling and Testing.

- a. **In-Place Density.** For every 500 tons of compacted asphaltic material or as directed by the Engineer, test the in place density. The in place density shall be in the range of 92.0% to 97.0% of the maximum density. Do not increase the asphalt content of the mixture to increase pavement density.

Unless otherwise shown on the plans, obtain 2 roadway specimens at each location selected by the Engineer for in-place density determination. Unless otherwise determined, the Engineer will witness the coring operation and measurement of the core thickness. Unless otherwise approved, obtain the cores within 1 working day after placement is completed. Obtain two 6 inch diameter cores side-by-side from within 1 foot of the location provided by the Engineer. For Type C, D and F mixtures, 4 inch diameter cores are allowed. Mark the cores for identification.

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

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

If the core heights exceed the minimum untrimmed values listed in Table 8, trim the cores within 1 working day following placement operations unless otherwise approved. If the core height before trimming is less than the minimum untrimmed value shown in Table 8, decide whether or not to include the pair of cores in the density determination for that subplot. If the cores are to be included in density determination, trim the cores. If the cores will not be included in density determination, store untrimmed cores for the Engineer.

The Engineer will measure density in accordance with Tex-207-F and Tex-227-F. Before drying to a constant weight, cores may be predried using a vacuum device, or by other methods approved by the Engineer, to remove excess moisture. The Engineer will use the average density of the 2 cores to calculate the in-place density at the selected location.

If the in-place density in the compacted mixture is below 92% or greater than 97%, change the production and placement operations to bring the in-place density within requirements. The Engineer may suspend production until the in-place density is brought to the required level, and may require a test section as described below, before proceeding.

At the onset of production, or after production and placement operations have been altered to bring the in-place density into conformance, construct a test section of 1 lane-width and at most 0.2 miles in length to demonstrate that compaction to between 92.0% and 97.0% in-place density can be obtained. Continue this procedure until a test section with the correct density can be produced. The Engineer will allow only 2 test sections per day. When a test section producing satisfactory in-place air void content is placed, resume full production.

(1) Shoulders and Ramps. Shoulders and ramps are subject to in-place density testing, unless otherwise shown on the plans.

(2) Miscellaneous Areas. Miscellaneous areas include areas that are not generally

subject to primary traffic, such as driveways, mailbox turnouts, crossovers, gores, spot level-up areas, and other similar areas. Miscellaneous areas also include level-ups and thin overlays if the layer thickness designated on the plans is less than the compacted lift thickness shown in Table 8.

Miscellaneous areas will not be included in the in place density testing. Compact areas that are not subject to in-place air void determination in accordance with ordinary compaction control.

- b. Segregation (Density Profile).** If shown on the plans, test for segregation using density profiles in accordance with Tex-207-F, Part V. Provide the Engineer with the results of the density profiles as they are completed. Areas defined as “Miscellaneous Areas,” are not subject to density profile testing.

If density profiles are required by the plans, perform a density profile every time the screed stops, on areas that are identified by either the Contractor or the Engineer as having thermal segregation, and on any visibly segregated areas. If the screed does not stop, and there are no visibly segregated areas or areas that are identified as having thermal segregation, perform a minimum of 1 profile per 500 tons of compacted material or as directed by the Engineer.

Reduce the test frequency to a minimum of 1 profile per 2,000 tons of compacted material, or as directed by the Engineer, if 4 consecutive profiles are within established tolerances. Continue testing at this frequency unless a profile fails, at which point resume testing at a minimum frequency of 1 per 500 tons or as directed by the Engineer. The Engineer may further reduce the testing frequency based on a consistent pattern of satisfactory results.

Unless otherwise shown on the plans, the density profile is considered failing if it exceeds the tolerances in Table 11. The Engineer may make as many independent density profile verifications as deemed necessary. The Engineer’s density profile results will be used when available.

Investigate density profile failures and take corrective actions during production and placement to eliminate the segregation. Suspend production if 2 consecutive density profiles fail, unless otherwise approved. Resume production after the Engineer approves changes to production or placement methods.

**Table 11
Segregation (Density Profile) Acceptance Criteria**

Mixture Type	Maximum Allowable Density Range (Highest to Lowest)	Maximum Allowable Density Range (Average to Lowest)
Type A & Type B	8.0 pcf	5.0 pcf
Type C, Type D, & Type F	6.0 pcf	3.0 pcf

- c. Longitudinal Joint Density.**

(1) Informational Tests. While establishing the rolling pattern, perform joint density evaluations and verify that the joint density is no more than 3.0 pounds per cubic foot below the density taken at or near the center of the mat. Adjust the rolling pattern if needed to achieve the desired joint density. Perform additional joint density evaluations at least once per subplot unless otherwise directed.

(2) Record Tests. If shown on the plans, for each 500 tons of compacted material or as directed by the Engineer, perform a joint density evaluation at each pavement

edge that is or will become a longitudinal joint. Determine the joint density in accordance with Tex-207-F, Part VII. Record the joint density information and submit results to the Engineer. The evaluation is considered failing if the joint density is more than 3.0 pounds per cubic foot below the density taken at the core random sample location and the correlated joint density is less than 90.0%. The Engineer may make independent joint density verifications at the random sample locations. The Engineer's joint density test results will be used when available.

Investigate joint density failures and take corrective actions during production and placement to improve the joint density. Suspend production if 2 consecutive evaluations fail unless otherwise approved. Resume production after the Engineer approves changes to production or placement methods.

- d. **Recovered Asphalt DSR.** The Engineer may take production samples or cores from suspect areas of the project to determine recovered asphalt properties. Asphalt binders with an aging ratio greater than 3.5 do not meet the requirements for recovered asphalt properties and may be deemed defective when tested and evaluated by the Engineer. The aging ratio is the dynamic shear rheometer (DSR) value of the extracted binder divided by the DSR value of the original unaged binder (including RAP binder). DSR values are obtained according to AASHTO T 315 at the specified high temperature performance grade of the asphalt. The binder from RAP will be included proportionally as part of the original unaged binder. The Engineer may require removal and replacement of the defective material at the Contractor's expense. The asphalt binder will be recovered for testing from production samples or cores using Tex-211-F.
- e. **Irregularities.** Immediately take corrective action if surface irregularities, including but not limited to segregation, rutting, raveling, flushing, fat spots, mat slippage, color, texture, roller marks, tears, gouges, streaks, or uncoated aggregate particles, are detected.

The Engineer may allow placement to continue for at most 1 day of production while taking appropriate action. If the problem still exists after that day, suspend paving until the problem is corrected to the satisfaction of the Engineer.

To the satisfaction of the Engineer, remove and replace any mixture that does not bond to the existing pavement or that has other surface irregularities identified above.

- 3. **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, 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 7, payment will be made for the load. If test results are not within operational tolerances, no payment will be made for the load and the Engineer may require removal.
- 4. **Ride Quality.** When required by the plans, measure ride quality in accordance with TxDOT Standard Specification Item 585, "Ride Quality for Pavement Surfaces." Surface Test Type A or B as well as Pay Schedule 1, 2, or 3 shall also be indicated on the plans.

ITEM 206

ASPHALT TREATED BASE

206.1. DESCRIPTION: *Construct a base or foundation course composed of a compacted mixture of aggregate and asphalt binder mixed hot in a mixing plant.*

206.2. 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. When a source change occurs, the Engineer will verify that the specification requirements are met and may require a new laboratory mixture design. Use TxDOT standard laboratory test procedure Tex-100-E for material definitions.

A. Aggregate. Furnish natural aggregates or crushed concrete unless otherwise shown on the plans. When shown on the plans, other recycled materials, including reclaimed asphalt concrete pavement (RAP), are allowed up to the maximum percentage shown on the plans. Stockpile aggregates for each source and type separately. Do not add material to an approved stockpile unless approved by the Engineer.

Furnish aggregates that conform to the requirements shown in Table 1 and specified in this Section unless otherwise shown on the plans. Each source must meet the requirements of Table 1. The Engineer may allow testing of the proposed combined aggregates, rather than each source, to meet Table 1 requirements.

Table 1
Aggregate Quality Requirements

Property	Test Method ¹	Specification Requirement
Wet ball mill, % max	Tex-116-E	50
Max increase, % passing #40		20
Los Angeles abrasion ² , % max	Tex-410-A	50
Liquid limit, max	Tex-104-E	40
Plasticity index, max	Tex-106-E	10
Sand equivalent, % min	Tex-203-F	40
Decantation ³ , % max	Tex-406-A	5.0
Crushed faces, % min	Tex-460-A	60

1. TxDOT standard laboratory test procedure.

2. Use only when shown on the plans, instead of wet ball mill test.

3. Required only for RAP stockpiles and recycled aggregates when more than 30% RAP is allowed.

B. Recycled Materials. The use of recycled materials is allowed only when shown on the plans. Crushed concrete, RAP (except for City furnished RAP), and other recycled materials must meet the requirements of this Article. Request approval to blend 2 or more sources of recycled materials.

1. Limits on Percentage. When RAP is allowed by the plans, use no more than 30% unless otherwise shown on the plans. The percentage limitations for other recycled materials will be as shown on the plans.

2. Recycled Material (Including Crushed Concrete) Requirements.

a. Contractor Furnished Recycled Materials. When the Contractor furnishes the recycled materials, including crushed concrete, the final product will be subject to the requirements of this Article and Table 2 for the grade specified. Certify compliance

with TxDOT's 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 TxDOT standard laboratory test procedure Tex-413-A. The unblended recycled materials (crushed concrete and RAP) must not exceed the decantation shown in Table 1. Test RAP without removing the asphalt. Do not use RAP that is contaminated by dirt or other objectionable material. Crushed concrete must be managed in a way to provide for uniform quality. The Engineer may require separate dedicated stockpiles in order to verify compliance.

When more than 30% Contractor-owned recycled materials is allowed and used, the individual materials are subject to the requirements of Table 1.

b. City Furnished Required Recycled Materials. When the City furnishes and requires the use of recycled materials, unless otherwise shown on the plans:

- City 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, and
- the final product, blended or unblended, will be subject to the requirements in Table 2.

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

c. City Furnished and Allowed Recycled Materials. When the City 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 this Article, Table 2, and the plans.

3. Recycled Material Sources. City-owned recycled material is available to the Contractor only when shown on the plans. The location, approximate asphalt content, and approximate gradation will be shown on the plans for City-owned RAP sources in a stockpile condition prior to Contract Execution. Assume that required City-owned RAP meets Table 1 requirements. Return unused City-owned recycled materials to the City 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 it in accordance with federal, state, and local regulations before project acceptance. Do not intermingle Contractor-owned recycled material with City-owned recycled material unless approved by the Engineer.

C. Asphalt Material. Furnish the type and grade of asphalt binder specified on the plans. Provide asphalt binder that meets requirements of TxDOT Item 300, "Asphalts, Oils and Emulsions." When more than 30% RAP is allowed and used, ensure that the new binder and recovered binder from the RAP, when blended proportionally, meet the PG binder designation shown on the plans.

D. Tack Coat. Unless otherwise shown on the plans or approved, furnish CSS 1H, SS 1H, or a PG binder with a minimum high temperature grade of PG 58 for tack coat binder and in accordance with Item 203 "Tack Coat" and TxDOT Item 300, "Asphalts, Oils, and

Emulsions.”

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 TxDOT Item 300, “Asphalts, Oils, and Emulsions.”

- E. Additives.** When shown on the plans, use the type and rate of additive specified. Other additives that facilitate mixing or improve the quality of the mix may be allowed when approved.

If lime or a liquid anti-stripping agent is used, add in accordance with TxDOT Item 301, “Asphalt Anti-stripping 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 fines back into the drum.

- 206.3. EQUIPMENT:** Provide machinery, tools, and equipment in accordance with TxDOT Item 320, “Equipment for Production, Hauling, and Placement of Hot-Mixed Asphalt Materials.”

- 206.4. CONSTRUCTION:** Produce, haul, place, and compact the specified mixture in accordance with the requirements of this Item.

- A. Mixture Design.** Using TxDOT standard laboratory test procedure Tex-126-E and the materials proposed for the project, the Engineer will determine the target asphalt content required to produce a mixture meeting the requirements in Table 2 for the grade shown on the plans. The gradation of the combined aggregates will be determined in accordance with TxDOT standard laboratory test procedure Tex-200-F, Part I. The Engineer may accept a design from the Contractor that is performed in accordance with TxDOT standard laboratory test procedure Tex-126-E. Reimburse the City for subsequent mixture designs or partial designs necessitated by changes in the material or requests by the Contractor.

The mixture must contain between 4.0% and 9.0% asphalt when designed in accordance with TxDOT standard laboratory test procedure Tex-126-E. The Engineer will evaluate the mixture for moisture susceptibility in accordance with TxDOT standard laboratory test procedure Tex-530-C unless otherwise shown on the plans. A maximum of 10% stripping is allowed unless otherwise shown on the plans. The test sample will be retained and used to establish a baseline for comparison to production results. The Engineer may waive this test if a similar design using the same materials has proven satisfactory.

Produce a trial batch using the proposed project materials and equipment in a large enough quantity to ensure that the mixture is representative of the mixture design. The City will verify the strength requirement in Table 2 is met. The Engineer may waive trial mixtures if similar designs have proven satisfactory.

Table 2
Mix Requirements

Master Gradation Bands				
Tex-200-F, Part I¹, % Passing by Weight				
Sieve Size	Grade 1	Grade 2	Grade 3	Grade 4
1-3/4"		100	100	As shown on the plans
1-1/2"	100	90-100		
1"	90-100			
3/8"	45-70			
#4	30-55	25-55		
#40	15-30	15-40	15-40	
Strength Requirements				
Slow strength, psi, min. ²	50	40	30	30 ³

1. TxDOT standard laboratory test procedure.

2. TxDOT standard laboratory test procedure Tex-126-E, at optimum asphalt content.

3. Unless a higher minimum strength is shown on the plans.

B. Production Operations. Produce 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 non-compliance to the specification.

- 1. Storage and Heating of Materials.** Do not heat the asphalt binder above the temperature specified in TxDOT Item 300, "Asphalts, Oils and Emulsions," or outside the manufacturer's recommended values. On a daily basis, provide the Engineer with the records of asphalt binder and hot mix asphalt discharge temperatures in accordance with TxDOT Item 320, "Equipment for Hot Mix Asphalt Materials." Unless otherwise approved, do not store hot mix for more than 12 hours or for a time period less than 12 hours that affects the quality of the mixture.
- 2. Mixing and Discharge of Materials.** Notify the Engineer of the target discharge temperature and produce the mixture within 25°F of the target. When ordinary compaction is used, the Engineer will select a target discharge temperature between 225°F and 350°F. 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. The City will not pay for or allow placement of any mixture produced at more than 350°F.

Control the mixing time and temperature so that substantially all moisture is removed from the mixture before discharging from the plant. The Engineer may perform TxDOT standard laboratory test procedure Tex-212-F, Part II, to verify that the mixture contains no more than 0.2% moisture by weight. The sample will be taken immediately after the mixture is discharged into the truck and tested promptly.

C. Hauling Operations. Before use, clean all truck beds to ensure that the mixture will not become contaminated. When a release agent is necessary, use a release agent on the approved list maintained by the TxDOT Construction Division to coat the truck bed.

D. Placement Operations. Prepare the surface by removing objectionable material such as moisture, dirt, sand, leaves and other loose impediments before placing the mixture. Coordinate mixture delivery and paver speed to ensure a continuous placement operation. Suspend placement operations when, in the opinion of the Engineer, a continuous paving operation is not maintained. 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 treated base by at least 6 inches. Place the mix adjacent to gutters and structures so that the pavement will drain properly.

- 1. Weather Conditions.** Tack coat and mixture may be placed only when the roadway surface temperature is 50°F or higher unless otherwise approved. Measure the roadway

surface temperature with a handheld infrared thermometer. Place tack coat or mixtures only when the Engineer determines that general weather conditions and moisture conditions of the roadway surface are suitable. The Engineer may waive placement temperature requirements.

2. **Tack Coat.** Clean the surface before placing the tack coat. Unless otherwise approved, apply tack coat uniformly at a rate between 0.04 and 0.10 gallon 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 tack coat when placed adjacent to curbs, gutters, and structures. Roll the tack coat with a pneumatic tire roller unless otherwise directed. The Engineer may use TxDOT standard laboratory test procedure Tex-243-F to verify that the tack coat has adequate adhesive properties. The Engineer may suspend paving operations until there is adequate adhesion. The Engineer may waive the requirement to place tack coat.
3. **Lay Down Operations.** Dump and spread the asphalt mixture on the approved prepared surface with a spreading and finishing machine. Place the material without tearing, shoving, gouging, or segregating the mixture.

Do not jar or bounce the finishing machine when loading it. Obtain the required lines and grades without hand finishing. The Engineer may authorize hand finishing when the mixture is:

- placed in a narrow strip along the edge of existing pavement,
- used to level small areas, or
- placed in small irregular areas where the use of a finishing machine is not practical.

Leveling courses and other areas may be spread with a motor grader when shown on the plans or approved.

When hot mix is placed in windrows, operate windrow pick-up equipment so that substantially all the mixture deposited on the roadbed is picked up and loaded into the spreading and finishing machine.

Adjust the hopper flow gates of the spreading and finishing machine to provide an adequate and consistent flow of material. Operate the augers at least 85% of the time. Keep the augers one-half to three-quarters full of mixture. Maintain an adequate flow of material to the center of the paver for the full width of the mat.

Immediately take appropriate corrective action if surface irregularities including but not limited to segregation, rutting, raveling, flushing, fat spots, mat slippage, color, texture, roller marks, tears, gouges, or streaks are detected. Continue placement for no more than 1 day of production while appropriate action is taken. If no appropriate corrective action is taken or if the problem still exists after 1 day, suspend paving until the Engineer approves further production.

- E. **Compaction.** Uniformly compact the pavement to the density requirements of this Item. Use the procedure described in TxDOT standard laboratory test procedure Tex-207-F, Part IV, to establish the rolling pattern. Do not use pneumatic tire rollers if excessive pickup of fines by roller tires occurs.

When using three-wheel, tandem, or vibratory rollers, first roll the joint with the adjacent pavement. Continue rolling longitudinally at the sides, proceeding toward the center of the pavement, and overlap successive trips by at least one foot unless otherwise directed. Make

alternate trips of the roller slightly different in length. Begin rolling of super-elevated curves at the low side and proceed toward the high side, unless otherwise directed.

When operating vibratory rollers:

- do not operate in vibrating mode when stationary;
- do not operate in vibrating mode when changing directions;
- do not operate in vibrating mode on mats with a plan depth of less than 1-½ in.;
- do not allow the roller to stand on pavement that has not been fully compacted;
- do not operate when in contact with the compacted, finished pavement structure layer;
- in case of over-vibration resulting in disruption of the compacted material, rework and recompact or replace the damaged material at the Contractor's expense;
- roll at a speed producing at least 10 blows per foot unless otherwise directed;
- keep the drums moist with water without using excess water; and
- do not drop diesel, gasoline, oil, grease, or other foreign matter on the pavement.

Where specific air void requirements are waived, furnish and operate compaction equipment as approved. Use lightly oiled tamps to thoroughly compact the edges of the pavement along curbs, headers, and similar structures and in locations that will not permit thorough compaction with rollers. The Engineer may require rolling with a trench roller on widened areas, in trenches, and in other limited areas.

In-place compaction control is required for all mixtures. Complete all rolling for compaction before the mixture temperature drops below 175°F. Unless otherwise shown on the plans, use density control.

- 1. Density Control.** Determine the number and type of rollers needed to obtain the required density. Operate the rollers in accordance with the requirements of this specification and as approved.

Place and compact material to the minimum density of 95 to 100 percent as determined by TxDOT standard laboratory test procedure Tex-126-E or as shown on the plans. The Engineer will determine laboratory-molded density in accordance with TxDOT standard laboratory test procedure Tex-126-E from material sampled at the plant. Actual in-place density will be determined in accordance with TxDOT standard laboratory test procedure Tex-126-E unless otherwise directed. Unless otherwise shown on the plans, obtain required roadway specimens as directed. The Engineer will measure air voids in accordance with TxDOT standard laboratory test procedure Tex-207-F. When a satisfactory correlation to results obtained in accordance with TxDOT standard laboratory test procedure Tex-126-E is shown, other methods of determining in-place compaction may be used.

If in-place density is more than 1.0 percentage point below minimum density, cease production immediately. If in-place density is between 0.1 and 1.0 percentage points below minimum density, investigate the causes and make the necessary corrections. If minimum density is not obtained within one full day of operation, cease production.

Resume production after placing a test section of one lane width and a maximum 0.2

miles long that demonstrates that minimum density can be obtained. Repeat this procedure until producing a test section that meets minimum density requirements. Place no more than 2 test sections per day. Increasing the asphalt content of the mixture to increase in-place density is allowed by approval only.

2. **Ordinary Compaction.** When ordinary compaction is required by the plans, furnish one three-wheel roller, one pneumatic tire roller, and one tandem roller, as directed, for each compaction operation. The Engineer may waive the use of the tandem roller when the surface is adequately smooth and further steel wheel rolling is shown to be ineffective. The Engineer may allow a vibratory roller to be substituted for the three-wheel roller, the tandem roller, or both. Use at least one pneumatic tire roller. Pneumatic tire rollers will provide a minimum of 80 psi ground contact pressure when used for compaction and a minimum of 55 psi ground contact pressure when used for kneading and sealing the surface. Provide additional rollers as directed.

Establish rolling patterns in accordance with TxDOT standard laboratory test procedure Tex-207-F, Part IV, unless otherwise directed. Follow the selected rolling pattern unless changes in mixture or placement conditions that affect compaction occur. When changes occur, establish a new rolling pattern.

F. Sampling and Testing.

1. Production Sampling.

- a. **Mixture Sampling.** The Engineer will obtain mixture samples in accordance with TxDOT standard laboratory test procedure Tex-222-F at a minimum frequency of one test every 2,000 tons produced and placed or each days production and placement quantity if less.

2. Production Testing.

The Engineer will perform production tests.

- a. **Operational Tolerances.** The Engineer will determine compliance with operational tolerances. The gradation of the aggregate must be within the master grading limits for the specified grade except that a tolerance of 2 percentage points is allowed on the sieve size for each mixture grade that shows 100% passing in Table 2.

Ensure that the asphalt content does not vary by more than 0.5 percentage points from the design target.

- b. **Individual Loads of Asphalt-Treated Base.** The Engineer retains the right to reject individual truckloads of asphalt-treated base when it is evident that the material quality is unacceptable. When a load is rejected for reasons other than temperature, the Contractor may request that the rejected load be tested. Make this request within 4 hours of rejection. If City test results are within the operational tolerances listed in Section 292.4.F.2.a, "Operational Tolerances," payment will be made for the load. If City test results are not within operational tolerances, no payment will be made for the load.

3. **Placement Sampling and Testing.** Obtain two 6 inch diameter cores side by side at locations selected by the Engineer for every 2,000 tons produced and placed or each days production and placement quantity if is less. Provide the Engineer an opportunity to witness the coring operation and measure the core thickness. Mark the cores for identification. Immediately after obtaining the cores, dry the core holes and tack the sides and bottom. Fill the hole with the same type of mixture and properly compact the mixture. Other methods of repairing the core holes are allowed when approved.

Trim the cores, if necessary, and deliver them to the Engineer within 1 working day following placement operations unless otherwise approved.

- a. In-Place Air Voids.** The Engineer will measure in-place air voids in accordance with TxDOT standard laboratory test procedures Tex-207-F and Tex-227-F to verify that in-place density requirements of Section 206.4.E.1, "Density Control," are met.
 - b. Irregularities.** Remove and replace, at the expense of the Contractor and to the satisfaction of the Engineer, any mixture that does not bond to the existing pavement or has other surface irregularities identified by the Engineer. Correct grade deviations greater than ¼ inch in 16 feet measured longitudinally or greater than ¼ inch over the entire width of the cross-section, as shown on the plans.
 - c. Production Binder Properties.** The Engineer may take cores or other production samples at random from the project to determine recovered asphalt properties. Asphalt binders with an aging ratio greater than 3.5 do not meet requirements for recovered asphalt properties and may be deemed defective when tested and evaluated by the Engineer. The aging ratio, as determined in accordance with laboratory test procedure AASHTO T-315, is the DSR value of the extracted binder divided by the DSR value of the original unaged binder. The binder from RAP will be included proportionally as part of the original unaged binder. The Engineer may require the defective material be removed and replaced at the Contractor's expense. The asphalt binder will be recovered for testing from cores in accordance with TxDOT standard laboratory test procedure Tex-211-F.
- G. Surface Finish.** Use Surface Test Type A in accordance with TxDOT Standard Specification Item 585, "Ride Quality for Pavement Surfaces," unless otherwise shown on the plans.
- H. Opening to Traffic.** Open the completed course to traffic when permitted or directed. If the surface ravels, flushes, ruts, or deteriorates in any manner before final acceptance, correct it at the Contractor's expense and to the satisfaction of the Engineer.

ITEM 207

SINGLE COURSE BITUMINOUS SLURRY SEAL

207.1. DESCRIPTION: *The work covered by this specification includes the design, testing, construction and quality control required for the proper application of slurry seal surface.*

207.2. APPLICABLE SPECIFICATIONS AND TEST METHODS:

A. Agencies.

AASHTO: American Association of State Highways and Transportation Officials
 ASTM: American Society for Testing and Materials
 ISSA: International Slurry Surfacing Association

B. Aggregate and Mineral Filler.

AASHTO	ASTM	Title
T2	D75	Sampling Mineral Aggregates
T27	C136	Sieve Analysis of Aggregates
T11	C117	Materials Finer than No. 200 in Mineral Aggregates
T176	D2419	Sand Equivalent Value of Soils and Fine Aggregate
T84	C128	Specific Gravity and Absorption of Fine Aggregate
T19	C29	Unit Weight of Aggregate
T96	C131	Resistance to Abrasion of Small-Size Coarse Aggregate by Use of the Los Angeles Machine
T37	D546	Sieve Analysis of Mineral Filler
T104	C88	Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
N/A	D242	Mineral Filler for Bituminous Paving Mixtures
T127	C183	Sampling Hydraulic Cement

C. Emulsified Asphalt.

AASHTO	ASTM	Title
T40	D140	Sampling Bituminous Materials
T59	D244	Testing Emulsified Asphalt
M140	D977	Specification for Emulsified Asphalt
M280	D2397	Mixing, Setting and Water Resistance Test To Identify A Quick-Set Emulsified Asphalt

D. Residue From Emulsion.

AASHTO	ASTM	Title
T59	D244	Residue by Evaporation
T49	C2397	Penetration 3.5 oz (100 gm) at 5 Seconds 77°F (25°C)

E. Slurry Seal System.

ASTM	ISSA	Title
N/A	TB 101	Guide for Sampling Slurry Mix for Extraction Test
N/A	TB 106	Measurement of Slurry Seal Consistency
N/A	TB 109	Test Method for Measurement of Excess Asphalt in Bituminous Mixtures by Use of a Loaded-Wheel Tester
N/A	TB 111	Outline Guide Design Procedure for Slurry Seal
N/A	TB 112	Method of Estimate Slurry Seal Spread Rates and To Measure Pavement Macrotexture
N/A	TB 114	Wet Stripping Test for Cured Slurry Seal Mixes

N/A	TB 115	Determination of Slurry Seal Compatibility
N/A	TB 39	Method of Classified Emulsified Asphalt, Aggregate Mixtures by Modified Cohesion Test Measurement of Set and Cure Characteristics
D3910	N/A	Design, Testing, and Construction of Slurry Seal
D2172	N/A	Quantitative Extraction of Bitumen for Bituminous Paving Mixtures

207.3. MATERIALS: Provide materials in conformance with the following Items and requirements:

A. General. The slurry seal shall consist of a mixture of an approved emulsified asphalt, mineral aggregate, mineral filler, water and specified additives, proportioned, mixed and uniformly spread over a properly prepared surface. The completed slurry seal shall leave a homogenous mat, adhere firmly to the prepared surface and have a skid resistant surface texture.

B. Asphalt Emulsion. The emulsion shall be SS-1H or CRS-2H in conformance with TxDOT Item 300, Section 2.D. "Emulsified Asphalt" with a 4% Latex additive milled into the emulsion by the emulsion manufacturer. All shipments of latex modified emulsion shall be accompanied by a shipping ticket and a certificate of compliance which shall be provided to the Engineer.

AASHTO	ASTM	Title	Specification Criteria
Test on Emulsion			
T59	D244	Residue After Distillation	60% Minimum
Test on Emulsion Residue			
T49	C2397	Penetration at 77°F (25°C)	40 – 90

C. Mineral Aggregate. Provide a crushed aggregate from a single source meeting the requirements of Table 1 and Table 2. Unless otherwise shown on the plans, furnish aggregate with a minimum "B" Surface Aggregate Classification (SAC) as defined in TxDOT's Bituminous Rated Source Quality Catalog (BRSQC). Include the amount of mineral filler added to the mix in determining the total minus No. 200 aggregate fraction.

Table 1
Aggregate Gradation Requirements
Tex-200-F, Part II (Washed)
Cumulative % Retained

Sieve Size	Type I	Type II	Type III
½"	0	0	0
⅜"	0	0	0 – 1
#4	0	0 – 10	6 – 14
#8	0 – 10	10 – 35	35 – 55
#16	10 – 35	30 – 55	54 – 75
#30	35 – 60	50 – 70	65 – 85
#50	58 – 75	70 – 82	75 – 90
#100	70 – 85	79 – 90	82 – 93
#200	80 – 90	85 – 95	85 – 95

Table 2
Aggregate Quality Requirements

Property	TxDOT Standard Laboratory Test Method	Requirement
Magnesium sulfate soundness, %, max. ¹	Tex-411-A	30
Sand equivalent value, %, min.	Tex-203-F	70
Los Angeles abrasion, %, max	Tex-410-A	30

1. Use design gradation for the soundness test.

D. Mineral Filler. Provide mineral filler that is free of lumps and foreign matter consisting of non-air-entrained cement meeting the requirements of DMS-4600, "Hydraulic Cement," or

hydrated lime meeting the requirements of DMS-6350, "Lime and Lime Slurry." The type and amount of mineral filler needed shall be determined by a laboratory mix design and will be considered as part of the aggregate gradation. An increase or decrease of less than one percent (1%) may be permitted when the micro-surfacing is being placed if it is found to be necessary for better consistency or set times.

E. Water. Provide water that is potable and free of harmful soluble salts.

F. Other Additives. Use approved additives as recommended by the emulsion manufacturer in the emulsion mix or in any of the component materials when necessary to adjust mix time in the field.

G. F. Job-Mix Formula (JMF). Provide a mix design conforming to the proportions shown in Table 3 and meeting the requirements shown in Table 4. The mix design is subject to verification using laboratory produced mixes or trial batch mix before approval.

Provide emulsion and aggregate that are compatible so that the mixing process will completely and uniformly coat the aggregate. Design the mix so that the mixture will have sufficient working life to allow for proper placement at the predicted ambient temperature and humidity.

Table 3
JMF Proportions

Material	Proportion
Residual Asphalt	Type I - 10.0 to 16.0% by wt. of dry aggregate Type II & III - 6.0 to 9.0% by wt. of dry aggregate
Mineral Filler (Hydraulic Cement or Hydrated Lime)	0.5 to 3.0% by wt. of dry aggregate
Field Control Additive	As required to provide control of break and cure
Water	As required to provide proper consistency

Table 4
JMF Requirements

Property	TxDOT Standard Laboratory Test Method	Requirement
Wet track abrasion, g/sq. ft., max. wear value	Tex-240-F, Part IV	75
Gradation (aggregate and mineral filler)	Tex-200-F, Part II (Washed)	Table 1
Mix time, controlled to 120 sec.	Tex-240-F, Part I	Pass

H. Rate of Application. The slurry seal mixture shall be of the proper consistency at all times, so as to provide the application rate required by the surface condition. Suggested application rates are based upon the weight of dry aggregate in the mixture. Application rates are affected by the unit weight of the aggregate.

Unless a specific aggregate type and application rate are shown in the plans, the following recommended aggregate types and average single application rates are suggested for the various street classifications and situations:

Aggregate Type	Suggested Placement Locations	Suggested Application Rate
Type I	Local Type A w/o Bus Traffic	8 - 12 lb/yd ²
Type II	Local Type A and B Streets	10 - 20 lb/yd ²
Type III	Collectors and Arterials Wheel Ruts	15 - 30 lb/yd ² See Section 239.4.K., "Ruts"

207.4. EQUIPMENT: All methods employed in performing the work and all equipment, tools, and machinery used for handling the material and executing any part of the work shall be subject to the approval of the Engineer before the work is started, and whenever found unsatisfactory they shall be changed and improved as required. All equipment, tools, machinery and containers used

must be kept clean and maintained in a satisfactory condition.

A. Mixing Equipment. Furnish a self-propelled slurry seal mixing machine with:

- self-loading devices to promote continuous laying operations;
- sufficient storage capacity for mixture materials;
- individual volume or weight controls that will proportion each material to be added to the mix;
- continuous flow mixing with a revolving multi-blade mixer capable of discharging the mixture on a continuous flow basis;
- opposite side driving stations;
- full hydrostatic control of the forward and reverse speed during operation;
- a water pressure system and nozzle-type spray bar immediately ahead of the spreader box and capable of spraying the roadway for the width of the spreader box;
- a mechanical-type spreader box equipped with paddles or other devices capable of agitating and spreading the materials throughout the box;
- a spreader box with devices capable of providing lateral movement or side shift abilities; and
- a spreader box with a front seal and adjustable rear strike-off. Provide an adjustable secondary rear strike-off, if required.

Calibrate and properly mark each control device that proportions the individual materials. Equip the aggregate feed with a revolution counter or similar device capable of determining the quantity of aggregate used at all times. Provide a positive-displacement-type emulsion pump with a revolution counter or similar device capable of determining the quantity of emulsion used at all times. Provide an approved mineral filler feeding system capable of uniformly and accurately metering the required material.

B. Scales. Scales used for weighing aggregates and emulsion must meet all requirements of TxDOT Item 520, "Weighing and Measuring Equipment." The weighing equipment for aggregates may be either a suspended hopper or a belt scale.

C. Asphalt Storage and Handling Equipment. When storage tanks are used, furnish a thermometer in each tank to indicate the asphalt temperature continuously. Keep equipment clean and free of leaks. Keep asphalt materials free from contamination.

D. Cleaning Equipment. Power brooms and blowers, air compressors, vacuum sweepers, water flushing equipment, and hand brooms shall be suitable for cleaning the pavement surface and cracks therein.

E. Auxiliary Equipment. Hand squeegees, shovels and other equipment shall be provided as necessary to perform the work.

207.5. CONSTRUCTION:

A. General. Produce, transport, and place slurry seal as specified in this Item or on the plans. The slurry mixture shall be of the desired consistency as it leaves the mixer and no additional

elements shall be added. No lumping, balling, or unmixed aggregate shall be permitted. No segregation of the emulsion and aggregate fines from the coarse aggregate will be permitted. If the coarse aggregate settles to the bottom of the mix, the slurry will be removed from the pavement. Care shall be taken not to overload the spreader box, which shall be towed at a slow and uniform rate not to exceed 5 miles per hour. The action of the squeegee in the spreader box shall permit free flow of the slurry into all surface voids and cracks. A sufficient amount of slurry seal shall be fed to the box to keep a full supply against the full width of the squeegee. The mixture shall not be permitted to overflow the front sides of the spreader box. Adjacent lanes shall be lapped at the edges a minimum dimension which will provide complete sealing at the overlap.

The fresh mix shall be protected by barricades and markers to permit drying. In areas where the spreader box cannot be used, the slurry shall be applied by means of hand squeegees. Any joints or cracks that are not filled by the slurry mixture shall be corrected by use of hand squeegees. Upon completion of the work, the slurry seal shall have no holes, bare spots, or cracks through which liquids or foreign matter could penetrate to the underlying pavement. The finished surface shall present a uniform and skid resistant appearance satisfactory to the Engineer. All wasted and unused material and all debris shall be removed from the site prior to final acceptance. Ensure that the finished surface has a uniform texture and the slurry seal mat is fully adhered to the underlying pavement.

B. Temporary Material Storage.

- 1. Aggregate Storage.** Stockpile materials in a manner that will prevent segregation or contamination. Remix stockpiles with suitable equipment when necessary to eliminate segregation. Use a scalping screen while transferring aggregates to the mixing machine to remove oversize material.
- 2. Mineral Filler Storage.** Store the mineral filler in a manner that will keep it dry and free from contamination.
- 3. Asphalt Material Storage.** Keep asphalt materials free from contamination.

- C. Weather Limitations.** Place the material when the atmospheric temperature is at least 50°F and rising and the surface temperature is at least 50°F. Cease placement when the atmospheric temperature is below 60°F and falling, when weather is foggy or rainy, or when rain is imminent as determined by the Engineer. Cease placement 24 hr. before forecasted temperatures below 32°F.

No slurry shall be applied under the following conditions:

- 1.** While puddles of water remain on the pavement surface to be sealed.
- 2.** When the weather is foggy.
- 3.** If there is a chance of rain before it can be cured properly.

Slurries that cure by evaporation should not be laid during periods of abnormally high humidity.

Any uncured slurry that is washed away from the roadway by rain or other water sources into yards, driveways, sidewalks, parkways, etc., shall be removed and cleaned by the Contractor at his expense. Open or underground drainage systems shall be removed and cleaned as directed by the Engineer at the Contractor's expense.

- D. Surface Preparation.** The Engineer shall approve the surface preparation prior to surfacing.

No dry aggregate either spilled from the lay-down machine or existing on the road, will be permitted.

- 1. Surface Cleaning.** Thoroughly clean the surface of all vegetation, loose aggregate, and soil. Remove existing raised pavement markers. When existing surface conditions require, provide a water spray immediately ahead of the spreader box. Apply water at a rate that will dampen the entire surface without any free-flowing water ahead of the spreader box. If water is used, cracks shall be allowed to dry thoroughly before applying slurry seal.
 - 2. Protection.** Manholes, valve boxes, drop inlets and other service entrances shall be protected from the slurry seal by a suitable method. The Contractor shall cover all raised pavement markers in a manner to protect and insure the integrity of the markers prior to placing the slurry seal and shall remove such covers after the completion of micro-surfacing so that the markers will remain fully functional. Any markers damaged by the Contractor's operations shall be repaired or replaced at no cost to the City.
 - 3. Tack Coat.** The Engineer may require a tack coat if the surface to be covered is extremely dry and raveled, or is concrete or brick. If required by the Engineer, the tack coat should consist of one part emulsified asphalt/three parts water. The emulsified asphalt should be the same as used in the mix. The distributor shall be capable of applying the dilution evenly at a rate of 0.05 to 0.10 gal/yd². The tack coat shall be allowed to cure before application of the slurry seal.
 - 4. Crack Pre-Treatment.** If shown on the plans, pre-treat the cracks in the surface with an acceptable crack sealer prior to the application of the micro-surfacing.
- E. Material Transfer.** Minimize construction joints by providing continuous loading of material while placing slurry seal. Ensure that oversized material has been removed prior to transferring the aggregates to the mixing machine.
- F. Placing.** Spread the mixture uniformly to the lines and grades shown on the plans or as directed by means of a mechanical type spreader box. Shift the spreader box when necessary to maintain proper alignment. Clean the spreader box as necessary to minimize clumps. Set and maintain the spreader box skids to prevent chatter in the finished mat. Prevent loss of material from the spreader box by maintaining contact between the front seal and the road surface. Adjust the rear seal to provide the desired spread. Adjust the secondary strike-off, if present, to provide the desired surface texture.
- G. Curing.** Protect the finished mat from traffic until the mix cures and will not be damaged by traffic. Adjust mixture properties according to humidity conditions and ambient air temperatures to allow uniformly moving traffic on completed travel lanes within 1 hr. after placement with no damage to the surface. Protect other locations subject to sharp turning or stopping and starting traffic for longer periods when necessary.
- H. Production Testing.** Provide access to the mixing unit discharge stream for sampling purposes. Produce a slurry seal mixture that will meet the tolerances specified in Table 5. Remove and replace or use other approved means to address material that does not meet these requirements, at no additional cost.

**Table
5
Production
Tests**

Property	TxDOT Standard Laboratory Test Method	Requirement
Asphalt content, % by wt.	Tex-236-F1 or asphalt meter readings	Design target $\pm 0.5\%$ and within limits of Table 1
Gradation, % retained	Tex-200-F, Part II (washed) ¹	#8 sieve and larger: ± 5 from design gradation. #16 sieve and smaller: ± 3 from design gradation. ²

1. Dried to constant wt. at 230°F $\pm 10^\circ$ F.

2. Material passing #200 sieve including the mineral filler must conform to the limitations of the master gradation shown in Table 1.

I. Workmanship. Remove and replace slurry material exhibiting evidence of poor workmanship at no additional cost.

1. Finished Surface. Provide a finished surface that has a uniform texture free from excessive scratch marks, tears, or other surface irregularities. Marks, tears, or irregularities are considered excessive if:

- more than 1 is at least ¼ inch wide and at least 10 feet long in any 100 feet of machine pull,
- more than 3 are at least ½ inch wide and more than 6 inches long in any 100 feet of machine pull, or
- any are 1 inch wide or wider and more than 4 inches in length.

2. Construction Joints. Place longitudinal joints on lane lines unless otherwise directed. Provide longitudinal and transverse joints that are uniform and neat in appearance. Provide construction joints that have limited buildup and that have no gaps between applications. Joints with buildup will be considered acceptable if:

- no more than ½ inch vertical space exists between the pavement surface and a 4 foot straightedge placed perpendicular to the longitudinal joint and
- no more than ¼ inch vertical space exists between the pavement surface and a 4 foot straightedge placed perpendicular to the transverse joint.

3. Edges. Provide an edge along the roadway centerline, lane lines, shoulder, edge of pavement, or curb line that is uniform and neat in appearance. The edge is considered acceptable when:

- it varies no more than ± 3 inches from a 100 foot straight line on a tangent section and
- it varies no more than ± 3 inches from a 100 foot arc on a curved section.

J. Miscellaneous Areas. Use a single-batch-type lay-down machine or other approved method to place materials on ramps or other short sections. Lightly dampen the surface before placing the mix. Provide 100% coverage that is uniform in appearance and comparable to that produced by the spreader box.

ITEM 208
SALVAGING, HAULING & STOCKPILING RECLAIMABLE
ASPHALTIC PAVEMENT

208.1. DESCRIPTION: *Salvage, by milling existing asphalt concrete pavement or asphalt-stabilized base, haul, and stockpile existing asphalt material.*

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

A. Milling (Planing) Machine. Use milling (planing) machines that:

1. have a minimum 6 foot cutting width except for work areas less than 6 feet wide;
2. are self-propelled with sufficient power, traction, and stability to maintain an accurate depth of cut and slope;
3. can cut in 1 continuous operation:
 - a. 4 inches of asphalt concrete pavement,
 - b. 1 inch of concrete pavement,
 - c. or a combination of 2 inches of asphalt concrete pavement and ½ inch of concrete pavement;
4. 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;
5. use transverse controls with an automatic system to control cross slope at a given rate;
6. use integral loading and reclaiming devices to allow cutting, removal, and discharge of the material into a truck in one operation; and
7. include devices to control dust created by the cutting action.

B. 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.

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

208.3. CONSTRUCTION: Remove dirt, raised pavement markings, and other debris, as directed. Unless otherwise shown on the plans, ensure that 95% of the reclaimed material passes a 2 inch sieve. Do not contaminate asphalt material during its removal, transportation, or storage. Repair pavement to remain that is damaged by the removal operations. Work performed under this item shall be prosecuted in such a manner as to cause minimum inconvenience to traffic or to the owners of adjacent property.

A. Grade Reference. When required, place grade reference points at maximum intervals of 50 feet. Use the control points to set the grade reference. Support the grade reference so the maximum deflection does not exceed 1/16 inch between supports.

- B. Milling (Planing).** 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 milled (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.

When an overlay on the milled (planed) pavement is not required, provide a minimum texture depth of not less than 0.05 inch. Stop milling (planing) operations when surface texture depth is not sufficient.

When located within 4 inches of steep curbs, water valves, draw grates, bridge joints, etc., asphaltic concrete that cannot be removed by the milling (planing) machine shall be removed by a manual system conforming to 208.2.B. "Manual System" or other methods acceptable to the Engineer.

When milling (planing) over a bridge deck, the milling depth shall not exceed 3/16 inch into the original deck surface of the bridge. Do not damage armor joints, sealed expansion joints, and other appurtenances.

Provide a pavement surface that, after milling (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 inch in 10 feet. Evaluate this criterion with a 10 foot 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. The pavement and curb surfaces shall be cleaned of all debris and left in a neat and presentable condition.

- C. Edge Treatments.** At the end of the day and for areas under traffic, slope vertical or near vertical longitudinal faces in the pavement surface in accordance with the requirements in the plans. Taper transverse faces to provide an acceptable ride.

ITEM 209 CONCRETE PAVEMENT

209.1. DESCRIPTION: *Construct hydraulic cement concrete pavement with or without curbs on the concrete pavement.*

209.2. MATERIALS:

A. Hydraulic Cement Concrete. Provide hydraulic cement concrete in accordance with Item 300, "Concrete," except that strength over-design is not required. Provide Class P concrete designed to meet a minimum average compressive strength of 3,000 psi at 7-days or a minimum average compressive strength of 4,000 psi at 28-days. Test in accordance with TxDOT standard laboratory test procedure Tex-448-A or Tex-418-A.

When shown on the plans or allowed, provide Class HES concrete for very early opening of small pavement areas or leave-outs to traffic. Design Class HES to meet the requirements of Class P and a minimum average compressive strength of 2,400 psi in 24-hours, unless other early strength and time requirements are shown on the plans or allowed. No strength over-design is required. Type III cement is allowed for Class HES concrete.

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.

B. Reinforcing Steel. Unless shown on the plans, provide Grade 60 deformed steel for bar reinforcement in accordance with Item 301, "Reinforcing Steel." Provide approved positioning and supporting devices (baskets and chairs) capable of securing and holding the reinforcing steel in proper position before and during paving in accordance with 209.B.3, "Positioning and Support Devices for Reinforcement and Joint Assemblies." Provide corrosion protection when shown on the plans.

1. Dowels. Provide smooth, straight dowels of the size shown on the plans, free of burrs, and conforming to the requirements of Item 301, "Reinforcing Steel." Coat dowels with a thin film of grease 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. Tie Bars. Provide straight deformed steel tie bars. Provide either multiple-piece tie bars or single-piece tie bars as shown on the plans. Provide multiple-piece tie bars composed of 2 pieces of deformed reinforcing steel with a coupling capable of developing a minimum tensile strength of 125% of the design yield strength of the deformed steel when tensile-tested in the assembled configuration. Provide a minimum length of 33 diameters of the deformed steel in each piece. Use multiple-piece tie bars from the list of "Prequalified Multiple Piece Tie Bar Producers" maintained by the TxDOT Construction Division, or submit samples for testing in accordance with TxDOT standard laboratory test procedure Tex-711-I. A laboratory test report from an independent laboratory that has conducted Tex-711-I on the unapproved multiple piece tie bar may also be submitted to the Engineer for consideration.

C. Positioning and Support Devices for Reinforcement and Joint Assemblies. These devices shall be of sufficient structural quality to prevent movement of the dowels or steel reinforcement during concrete placement and finishing. Devices shall be of a type approved by the Engineer.

Positioning and supporting devices (chairs) for steel reinforcement bars shall be either plastic or metal and of sufficient number to maintain the position of the bars within the allowable tolerances.

Metal positioning and supporting devices for expansion and contraction joint assemblies (such as welded wire bar chairs, bar stakes, etc.) where used shall be as shown on the plans or may be similar devices of equivalent or greater strength, approved by the Engineer. The support devices shall secure the joint assembly and dowels within the allowable tolerances while providing no restraint against joint movement. Dowels used in joint assemblies shall be secured in parallel position by a transverse metal brace of the type and design shown on the plans, or may be secured by other devices approved by the Engineer. The devices shall provide positive mechanical connection between the brace and each unit (other than by wire tie) and prevent transverse movement of each load transmission device.

- D. Curing Materials.** Provide Type 2 membrane curing compound conforming to TxDOT DMS-4650, "Hydraulic Cement Concrete Curing Materials and Evaporation Retardants." Provide SS-1 emulsified asphalt conforming to TxDOT Item 300, "Asphalts, Oils, and Emulsions," for concrete pavement to be overlaid with asphalt concrete under this Contract unless otherwise shown on the plans or approved. Provide materials for other methods of curing conforming to the requirements of Item 307, "Concrete Structures."
 - E. Epoxy.** Provide Type III epoxy in accordance with TxDOT DMS-6100, "Epoxies and Adhesives," for installing all drilled-in reinforcing steel.
 - F. Evaporation Retardant.** Provide evaporation retardant conforming to TxDOT DMS-4650, "Hydraulic Cement Concrete Curing Materials and Evaporation Retardants."
 - G. 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 TxDOT DMS-6310, "Joint Sealants and Fillers."
- 209.3. EQUIPMENT:** Furnish and maintain all equipment in good working condition. Use measuring, mixing, and delivery equipment conforming to the requirements of Item 300, "Concrete." Obtain approval for other equipment used.
- A. 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 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.

B. Forming Equipment.

- 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 foot radius or less.
- 2. Curb Forms.** Provide curb forms for separately placed curbs that are not slipformed that conform to the requirements of Item 500, "Concrete Curb, Gutter, and Concrete Curb and Gutter."

C. 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.

D. Texturing Equipment.

- 1. Carpet Drag.** Provide a carpet drag mounted on a work bridge or a 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. Use an artificial grass-type carpet having a molded polyethylene pile face with a blade length of $\frac{5}{8}$ to 1 inch, a minimum weight of 70 oz. per square yard, and a strong, durable, rot-resistant backing material bonded to the facing.
- 2. Tining Equipment.** Provide a self-propelled transverse metal tine device equipped with 4 to 6 inch steel tines and with cross-section approximately $\frac{1}{32}$ inch thick by $\frac{1}{12}$ inch wide, spaced at 1 inch, center-to-center. Hand-operated tining equipment that produces an equivalent texture may be used only on small or irregularly shaped areas or, when permitted, in emergencies due to equipment breakdown.

E. 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 Article 209.4.I, "Curing." Hand-operated pressurized spraying equipment with atomizing nozzles may be used on small or irregular areas or when permitted.

F. 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.

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

H. Testing Equipment. Provide testing equipment regardless of job-control testing responsibilities in accordance with Item 300, "Concrete," unless otherwise shown in the plans or specified.

I. Coring Equipment. When required, provide coring equipment capable of extracting cores in accordance with the requirements of TxDOT standard laboratory test procedure Tex-424-A.

J. Miscellaneous Equipment. Furnish both 10 foot and 15 foot steel or magnesium long-handled standard straightedges. Furnish enough work bridges, long enough to span the pavement, for finishing and inspection operations. Furnish date stencils to impress pavement placement dates into the fresh concrete, with numerals approximately 2 inches high by 1 inch wide by ¼ inch deep.

209.4. 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 sufficiently in advance of placing pavement concrete. Adequately light the active work areas for all nighttime operations. Provide and maintain tools and materials to perform testing.

A. Paving and Quality Control Plan. Unless otherwise shown on the plans, 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 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.

B. Job-Control Testing. Unless otherwise shown on the plans, perform all fresh and hardened concrete job-control testing at the specified frequency. Provide job-control testing personnel meeting the requirements of Item 300, "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, air, and temperature on start-up production days to check for concrete conformance and consistency. Sample and prepare strength test specimens (2 specimens per test) on the first day of production and for each 3,000 square yards or fraction thereof of concrete pavement thereafter. Prepare at least 1 set of strength-test specimens for each production day. Perform slump, air, 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.

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

1. Job-Control Strength. Unless otherwise shown on the plans or permitted by the Engineer, use 7-day job-control concrete strength testing in accordance with TxDOT standard laboratory test procedure Tex-418-A.

For 7-day job-control by compressive strength, use a compressive strength of 2,900 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 TxDOT standard laboratory test procedure Tex-427-A.

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

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, investigate the strength test procedures, the quality of materials, the concrete production operations, and other possible problem areas to determine the cause. 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. If any job-control strength is more than 15% below the required job-control strength, the Engineer may evaluate the structural adequacy of the pavements. When directed, remove and replace pavements found to be structurally inadequate at no additional cost.

2. **Split-Sample Verification Testing.** When indicated on the plans, 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 when 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 ¹	Allowable Differences
Temperature, Tex-422-A	2°F
Slump, Tex-415-A	1 inch
Air content, Tex-414-A or Tex-416-A	1%
Compressive strength, Tex-418-A	10%

¹ TxDOT standard laboratory test procedures

C. Reinforcing Steel and Joint Assemblies. Accurately place and secure in position all reinforcing steel as shown on the plans and in accordance with the requirements herein. 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 longitudinal reinforcement splices to avoid having more than 1/3 of the splices within a 2 foot longitudinal length of each lane of the pavement. Use multiple-piece tie bars or drill and epoxy grout tie bars at longitudinal construction joints. Verify that tie bars that are drilled and epoxied 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 E-488, except that alternate approved equipment may be used. All 15 tested bars must meet the required pullout strength. If any of the test results do not meet the required minimum pullout strength, perform corrective measures to provide equivalent pullout resistance. Repair damage from testing. Acceptable corrective measures include but are not limited to installation of additional or longer tie bars.

1. **Manual Placement.** Secure reinforcing bars at alternate intersections with wire ties or locking support chairs. Tie all splices with wire.
2. **Mechanical Placement.** If mechanical placement of reinforcement results in steel misalignment or improper location, poor concrete consolidation, or other inadequacies, complete the work using manual methods.

D. Joints. Install joints as shown on the plans. Joint sealants are not required on concrete pavement that is to be overlaid with asphaltic materials. Clean and seal joints in accordance with TxDOT Item 438, "Cleaning and Sealing Joints and Cracks (Rigid Pavement and Bridge Decks)." Repair excessive spalling of the joint saw groove using an approved method before installing the sealant. Seal all joints before opening the pavement to all traffic. When placing of concrete is stopped, install a rigid transverse bulkhead, accurately notched for the reinforcing steel and shaped accurately to the cross-section of the pavement.

1. Placing Reinforcement at Joints. Where the plans require an assembly of parts at pavement joints, complete and place the assembly at the required location and elevation with all parts rigidly secured in the required position. Accurately notch joint materials for the reinforcing steel.

2. Transverse Construction Joints.

a. Jointed Concrete Pavement. When the placing of concrete is intentionally stopped, install and rigidly secure a complete joint assembly and bulkhead in the planned transverse contraction joint location. When the placing of concrete is unintentionally stopped, install a transverse construction joint either at a planned transverse contraction joint location or mid-slab between planned transverse contraction joints. For mid-slab construction joints, install tie bars of the size and spacing used in the longitudinal joints.

b. 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. For non-monolithic curbs, place reinforcing steel into the plastic concrete pavement 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 500, "Concrete Curb, Gutter, and Curb and Gutter."

E. 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 $\frac{1}{8}$ inch 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 hours after form removal unless otherwise approved. Clean joint face and repair honeycombed or damaged areas within 24 hours after a bulkhead for a transverse construction joint has been removed unless otherwise approved. When forms are removed before 72 hours after concrete placement, promptly apply membrane curing compound to the edge of the concrete pavement.

Forms that are not the same depth as the pavement but are within 2 inches 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 foot radius or less.

- F. 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 inches. Segregated concrete is subject to rejection. Place agitated concrete within 60 minutes after batching. Place non-agitated concrete within 45 minutes after batching. In hot weather or under conditions causing quick setting of the concrete, times may be reduced by the Engineer. Time limitations may be extended if the Contractor can demonstrate that the concrete can be properly placed, consolidated, and finished without the use of additional water.
- G. Concrete Placement.** Do not allow the pavement edge to deviate from the established paving line by more than ½ inch at any point. Place the concrete as near as possible to its final location, and minimize segregation and re-handling. Where hand spreading is necessary, distribute concrete using shovels. Do not use rakes or vibrators to distribute concrete.
- 1. Pavement.** 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 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.
 - 2. Date Imprinting.** Imprint dates in the fresh concrete indicating the date of the concrete placement. Make impressions approximately 1 foot from the outside longitudinal construction joint or edge of pavement and approximately 1 foot from the transverse construction joint at the beginning of the placement day. Orient the impressions to be read from the outside shoulder in the direction of final traffic. Impress date in DD MM YY format. Imprinting of the Contractor name or logo in similar size characters to the date is allowed.
 - 3. Curbs.** Where curbs are placed separately, conform to the requirements of Item 500, "Concrete Curb, Gutter, and Curb and Gutter."
 - 4. Temperature Restrictions.** Place concrete that is between 40°F and 95°F when measured in accordance with TxDOT standard laboratory test procedure 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. When temperatures warrant protection against freezing, protect the pavement with an approved insulating material capable of protecting the concrete for the specified curing period. Submit for approval proposed measures to protect the concrete from anticipated freezing weather for the first 72-hours after placement. Repair or replace all concrete damaged by freezing.

- H. Spreading and Finishing.** Unless otherwise shown on the plans, finish all concrete pavements with approved self-propelled equipment. Use power-driven spreaders, power-driven vibrators, power-driven strike-off, and 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.

1. **Finished Surface.** Perform sufficient checks with long-handled 10 foot and 15 foot straightedges on the plastic concrete to ensure that the final surface is within the tolerances specified in Surface Test A in TxDOT standard test procedure Item 585, "Ride Quality for Pavement Surfaces." Check with the straightedge parallel to the centerline.
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 rate recommended by the manufacturer. 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 shut down of pavement operations.
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 for all areas with a posted speed limit in excess of 45 mph. A metal-tine texture finish is required unless otherwise shown on the plans for areas with a posted speed limit less than 45 mph. Immediately following the carpet drag, apply a single coat of evaporation retardant at a 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 spaced at 1 inch, approximately 3/16 inch deep, with a minimum depth of 1/8 inch, and approximately 1/12 inch wide. Do not overlap a previously tined area. Use manual methods to achieve similar results on ramps and other irregular 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.

When carpet drag is the only surface texture required by the plans, ensure that adequate and consistent micro-texture is achieved by applying sufficient weight to the carpet and keeping the carpet from getting plugged with grout, as directed by the Engineer. Target a carpet drag texture of .04 inch, as measured by Tex-436-A Correct any location with a texture less than .03 inch 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. **Small or Irregular Placements.** Where machine placements and finishing of concrete pavement are not practical, use hand equipment and procedures that produce a consolidated and finished pavement section to the line and grade.
 5. **Emergency Procedures.** Use hand-operated equipment for applying texture, evaporation retardant, and cure in the event of equipment breakdown.
- I. **Curing.** Keep the concrete pavement surface from drying as described in Section 209.4.H.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 hour period when either the temperature taken in the shade away from artificial heat is above 50°F for at least 19 hours or when the surface temperature of the concrete is maintained above 40°F for 24 hours. Curing begins when the concrete curing system has been applied. Stop concrete paving if curing compound is not being applied promptly and maintained adequately. Other methods of curing in accordance with Item 307, "Concrete Structures," may be used when specified or approved.

- 1. Membrane Curing.** Spray the concrete surface uniformly with 2 coats of membrane curing compound at an individual application rate of not more than 180 square feet per gallon. Do not allow the concrete surface to dry before applying the curing compound. Use a towel or absorptive fabric to remove any standing pools of bleed water that may be present on the surface before applying the curing compound. Apply the first coat within 10 min. after completing texturing operations. Apply the second coat within 30 minutes after completing texturing operations.

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

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, apply additional compound at the same rate of coverage to correct the damage. Ensure that the curing compound coats the sides of the tining grooves.

- 2. Asphalt Curing.** When an asphaltic concrete overlay is required, apply a uniform coating of asphalt curing at a rate of 90 to 180 square feet per gallon as required. Apply curing immediately after texturing and just after 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.
- 3. Curing Class HES Concrete.** For all Class HES concrete pavement, provide membrane curing in accordance with Section 209.4.I.1, "Membrane Curing," followed promptly by water curing until opening strength is achieved but not less than 24 hours.

- J. 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 hours of curing.

- K. 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 in the plans or directed. Testing result interpretation for opening to traffic is subject to the approval of the Engineer.

- 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. Before opening to traffic, protect the pavement from damage due to crossings using approved methods. 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.

2. **Opening Pavement to All Traffic.** Pavement that is 7 days old may be opened to all traffic. Before opening to traffic, clean pavement, place stable material against the pavement edges, seal joints, and perform all other traffic safety related work.
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 hours old and opening strength has been demonstrated in accordance with Section 209.4.K.4, “Early Opening to All Traffic,” before curing is complete. Keep delivery equipment at least 2-feet from the edge of the concrete pavement. Keep tracks of the paving equipment at least 1 foot 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. **Early Opening to All Traffic.** Concrete pavement may be opened after curing is complete and the concrete has attained a compressive strength of 2,600 psi, except that pavement using Class HES concrete may be opened after 24 hours if the specified strength is achieved.
 - a. **Strength Testing.** Test concrete specimens cured under the same conditions as the portion of the pavement involved.
 - b. **Maturity Method.** Unless otherwise shown on the plans, the maturity method, TxDOT standard laboratory test procedure Tex-426-A, may be used to estimate concrete strength for early opening pavement to traffic. Install at least 2 maturity thermocouples for each day’s placement in areas where the maturity method will be used for early opening. Thermocouples, 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 TxDOT standard laboratory test procedure Tex-426-A, starting with the first day’s placement corresponding to the early opening pavement section.

After the first day, verify the strength–maturity relationship at least every 10 days of production. 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.

When the maturity method is used intermittently or for only specific areas, the frequency of verification will be as determined by the Engineer.

5. **Emergency Opening to Traffic.** Under emergency conditions, when the pavement is at least 72 hours old, open the pavement to traffic 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.

L. Pavement Thickness. Unless otherwise shown on the plans, the Engineer will perform 1 thickness test consisting of 1 reading at approximately the center of each lane every 500 feet or fraction thereof. The Engineer will check the thickness in accordance with TxDOT standard laboratory test procedure Tex-423-A unless other methods are shown on the plans. Core where directed in accordance with TxDOT standard laboratory test procedure Tex-424-A to verify deficiencies of more than 0.2 inch from plan thickness and to determine the limits of deficiencies of more than 0.75 inch from plan thickness. Fill core holes using a concrete mixture and method approved by the Engineer.

- 1. Thickness Deficiencies Greater than 0.2-inch.** When any depth test measured in accordance with TxDOT standard laboratory test procedure Tex-423-A is deficient by more than 0.2 inch from the plan thickness, take one 4-inch diameter core at that location to verify the measurement.

If the core is deficient by more than 0.2 inch but not by more than 0.75 inch from the plan thickness, take 2 additional cores from the unit (as defined in Section 209.4.L.3, "Pavement Units for Payment Adjustment") at intervals of at least 150 feet and at locations selected by the Engineer, 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 inch will be considered as the specified thickness plus 0.2 inch.

- 2. Thickness Deficiencies Greater than 0.75-inch.** If a core is deficient by more than 0.75 inch, take additional cores at 10 foot intervals in each direction parallel to the centerline to determine the boundary of the deficient area. The Engineer will evaluate any area of pavement found deficient in thickness by more than 0.75 inch but not more than 1 inch. As directed, remove and replace the deficient areas without additional compensation or retain deficient areas without compensation. Remove and replace any area of pavement found deficient in thickness by more than 1 inch without additional compensation.
- 3. Pavement Units for Payment Adjustment.** Limits for applying a payment adjustment for deficient pavement thickness from 0.2 inch to not more than 0.75 inch are 500-feet of pavement in each lane. Lane width will be as shown on typical sections and pavement design standards.

For greater than 0.75 inch 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 inch deficient will be subject to the payment adjustment based on the average core thickness at each end of the 10 foot interval investigation as determined by the Engineer.

Shoulders will be measured for thickness unless otherwise shown on the plans. Shoulders 6 feet wide or wider will be considered as lanes. Shoulders less than 6 feet 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 feet in length. Areas less than 500 feet in length will be individually evaluated for payment adjustment based on the plan area.

M. Ride Quality. When required by the plans, measure ride quality in accordance with TxDOT Item 585, "Ride Quality for Pavement Surfaces." Surface Test Type A or B as well as Pay Schedule 1, 2, or 3 shall also be indicated on the plans.

ITEM 210 ROLLING

210.1. 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.

210.2. EQUIPMENT: The Contractor may use any type of roller to meet the production rates and quality requirements of the Contract unless otherwise shown on the plans or directed. When specific types of equipment are required, use equipment that meets the requirements of this Article. 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 Requirements¹**

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

1. Unless otherwise specified in the Contract.

1 ton = 0.9 megagrams; 1 psi = 6.9 kPa, 1 lb = 0.45 kg, 1 in = 25.4 mm, 1 mph = 1 kph

A. 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. Confirm all wheels are flat. When static steel wheel rollers are required, vibratory rollers in the static mode may be used.

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

of wheel width.

B. Tamping Rollers. Furnish self-propelled rollers with at least 1 self-cleaning metal tamping drum capable of operating in a forward or backward motion with a minimum effective rolling width of 5 feet. For rollers with more than 1 drum, mount drums in a frame so that each drum moves independently of the other. Operate rollers in static or vibratory mode.

1. Tamping Roller (Minimum Requirement). For all tamping rollers except for heavy tamping rollers, provide tamping feet that exert a static load of 125 to 550 psi and extend outward at least 3 inches from the surface of the drum.

2. Heavy Tamping Roller. Provide tamping rollers that have:

- 2 metal tamping drums, rolls, or shells, each with a 60 inch minimum diameter and a 5 foot minimum width, or
- 1 rear and 2 forward drums, each with a 60 inch 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 feet.

Equip drums with tamping feet that:

- extend outward at least 7 inches from the drum surface,
- have an area of 7 to 21 square inches,
- 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.

C. Vibratory Rollers. Furnish self-propelled rollers with at least 1 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.

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

drum.

2. **Drum (Type B).** Furnish a roller with a minimum static weight of 6 tons and a vibratory drum.
3. **Drum (Type C).** Furnish a roller as shown on plans.

D. 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. When necessary, moisten the wheels with water or an approved asphalt release agent.

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.

1. **Light Pneumatic Tire.** Furnish a unit:

- with at least 9 pneumatic tires,
- with an effective rolling width of approximately 5 feet,
- 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. **Medium Pneumatic Tire.** Furnish a unit:

- with at least 7 pneumatic tires,
- with an effective rolling width of approximately 7 feet,
- 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.

3. **Heavy Pneumatic Tire.** Furnish a unit:

- with at least 4 pneumatic-tired wheels mounted on axles carrying at most 2 wheels,
- with wheels arranged to carry approximately equal loads on uneven surfaces,
- with a width between 8 and 10 feet 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.

- E. Grid Rollers.** Furnish rollers that have 2 cylindrical cages with a minimum diameter of 66-inches and a minimum width of 32 inches. Mount cages in a rigid frame with weight boxes. Use a cage surface of cast or welded steel fabric grid with bars 1-½ inches wide, spaced on 5 inch centers in each direction, that undulate approximately 1-inch 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

- F. Alternate Equipment.** Instead of the specified equipment, the Contractor may, as approved, operate other compaction equipment that produces equivalent results. Discontinue the use of the alternate equipment and furnish the specified equipment if the desired results are not achieved.

210.2. 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.

ITEM 220

BLADING

- 220.1. DESCRIPTION:** *Blade portions of the project limits as shown on the plans or as directed by the Engineer.*
- 220.2. EQUIPMENT:** All equipment shall be approved by the Engineer prior to use and shall be able to efficiently produce the desired results. When work is measured and paid by the number of hours of blading, use a dual or four-wheel drive power maintainer equipped with pneumatic tires, a blade of at least 12 feet in length, and a wheelbase of not less than 16 feet. If the maintainer is not equipped with a scarifier attachment, provide a scarifier.
- 220.3. CONSTRUCTION:** Blade all areas to the section, line and grade shown on the plans. Use a scarifier when necessary to loosen materials prior to 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.

ITEM 230

BASE AND PAVEMENT REPLACEMENT

- 230.1. DESCRIPTION:** *Repair localized sections of flexible pavement and full depth repair of concrete pavement including subgrade, base, and surfacing as shown on the plans due to distress from traffic loading, environment, or other causes. Cutting and replacing existing pavements for utility trench construction (cuts up to 6 feet in width) is specified in Item 511, "Cutting and Replacing Pavements (Trench Repair)."*
- 230.2. MATERIALS:** Furnish materials in accordance with the requirements herein unless otherwise shown on the plans. Provide materials of the type and grade as shown on the plans and in accordance with the pertinent Items listed below:
- A. Embankment.** Item 107, "Embankment."
 - B. Lime Treated Subgrade.** Item 108, "Lime Treated Subgrade."
 - C. Cement Treated Subgrade.** Item 109, "Cement Treated Subgrade."
 - D. Flexible Base.** Item 200, "Flexible Base."
 - E. Cement Treated Base.** Item 201, "Cement Treated Base."
 - F. Asphalt Treated Base.** Item 206, "Asphalt Treated Base."
 - G. Prime Coat.** Item 202, "Prime Coat."
 - H. Surface Treatments.** Item 204, "Surface Treatments."
 - I. Hot Mix Asphaltic Concrete Pavement.** Item 205, "Hot Mixed Asphaltic Concrete Pavement."
 - J. Concrete Pavement.** Item 209, "Concrete Pavements."
 - K. Concrete.** Item 300, "Concrete."
 - L. Reinforcing Steel.** Item 301, "Reinforcing Steel."
 - M. Epoxy.** TxDOT DMS 6100, "Epoxies and Adhesives."
- 230.3. EQUIPMENT:** Furnish equipment in accordance with the pertinent Items. Use of a motor grader will be permitted for asphalt concrete pavement unless otherwise shown on the plans.
- 230.4. CONSTRUCTION:** Repair using one or more of the following operations as 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.
- A. Removing Pavement Structure.** All concrete and asphaltic concrete pavements shall be cut with a concrete saw or other approved equally capable equipment. If necessary, remove adjacent soil and vegetation to prevent contamination of the repair area, and place it in a windrow. Do not damage adjacent pavement structure during repair operations.
 - 1. Existing Flexible Pavement.** The depth of the cut shall be such that upon removal of asphaltic concrete, the sides of the cut will be straight and square. Where existing base

materials are to remain, pavements shall be removed to their full depth up to the top of the base material. Care shall be taken not to damage the existing base. If subgrade work is required, remove flexible pavement structure layers from work area.

2. **Existing Concrete Pavement.** Remove areas identified by the Engineer. Make repair areas rectangular, at least 6 feet long and at least ½ a full lane in width unless otherwise shown on the plans. Saw-cut and remove existing asphalt concrete overlay over the repair area and at least 6 inches outside each end of the repair area. Saw-cut full depth through the concrete around the perimeter of the repair area before removal. Do not spall or fracture concrete adjacent to the repair area. Schedule work so that concrete placement follows full-depth saw cutting by no more than 7 days unless otherwise shown on the plans or approved.

Remove or repair loose or damaged base material, and replace or repair it with approved base material to the original top of base grade. Place a polyethylene sheet at least 4 mils thick as a bond breaker at the interface of the base and new pavement. Allow concrete used as base material to attain sufficient strength to prevent displacement when placing pavement concrete.

- B. **Preparing Subgrade.** Fill holes, ruts, and depressions with approved material. If required, thoroughly wet, reshape, and compact the subgrade as directed.

Where subgrade has failed, remove unstable subgrade material to the depth directed and replace with an approved material.

- C. **Mixing and Placing Base Material.** Place, spread, and compact material in accordance with the applicable Item to the required or directed depth. For flexible pavement repair, when bituminous material is to remain in the pavement structure, pulverize to a maximum dimension of 2-½ inches and uniformly mix with existing base to the depth shown on the plans.

1. **Flexible Base.** Use existing base and add new flexible base as required in accordance with Item 200, "Flexible Base," and details shown on the plans to achieve required section.
2. **Cement-Treated Base.** Use existing base, add flexible base, and stabilize with a minimum cement content of 4% by weight of the total mixture. Construct in accordance with details shown on the plans and Item 201, "Cement Treated Base," to achieve required section.
3. **Asphalt-Treated Base.** Place asphalt-treated base in accordance with details shown on the plans and Item 206, "Asphalt Treated Base," or Item 205, "Hot Mix Asphaltic Concrete Pavement," to achieve required section.
4. **Concrete Base.** Unless otherwise shown on the plans or permitted, furnish pavement concrete for replacement base material when required. The Engineer may waive quality control tests for base material.

- D. **Curing Base.** Cure in accordance with the appropriate Item unless otherwise directed or approved by the Engineer. Maintain completed base sections until surfacing.

- E. **Surfacing.** Apply surfacing with materials as shown on the plans to the completed base section.

1. **Prime Coat.** Protect the compacted, finished, and cured flexible or cement-treated 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.

2. **Surface Treatments.** Apply surface treatment with the type and grade of asphalt and aggregate as shown on the plans in accordance with Item 204, "Surface Treatments."
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 205, "Hot Mix Asphaltic Concrete Pavement," to achieve required section.
4. **Portland Cement Concrete Pavement.** Use only drilling operations that do not damage the surrounding operations when drilling holes for replacement steel. Place new deformed reinforcing steel bars of the same size and spacing as the bars removed or as shown on the plans. Lap all reinforcing steel splices in accordance with Item 301, "Reinforcing Steel." Place dowel bars and tiebars as shown on the plans. Epoxy-grout all tiebars for at least a 12 inch embedment into existing concrete. Completely fill the tiebar hole with Type III, Class A or Class C epoxy before inserting the tiebar into the hole.

Provide grout retention disks for all tiebar holes. Provide and place approved supports to firmly hold the new reinforcing steel, tiebars, and dowel bars in place. Demonstrate, through simulated job conditions, that the bond strength of the epoxy-grouted tiebars meets a pullout strength of at least $\frac{3}{4}$ of the yield strength of the tiebar when tested in accordance with ASTM E 488 within 18 hr. after grouting. Increase embedment depth and retest when necessary to meet testing requirements. Perform tiebar testing before starting repair work.

If the time frame designated for opening to traffic is less than 72 hours after concrete placement, provide Class HES concrete designed to attain a minimum average flexural strength of 255 psi or a minimum average compressive strength of 1,800 psi within the designated time frame. Otherwise provide Class P concrete conforming to Item 209, "Concrete Pavement." Type III cement is permitted for Class HES concrete. Mix, place, cure, and test concrete to the requirements of Item 209, "Concrete Pavement," and Item 300, "Concrete," unless otherwise shown on the plans. Broom-finish the concrete surface unless otherwise shown on the plans.

Match the grade and alignment of existing concrete pavement. After concrete strength requirements have been met, replace any asphalt overlay and shoulder material removed with new asphalt concrete material in accordance with Item 205, "Hot Mixed Asphaltic Concrete Pavement."

For repair areas to be opened to traffic before 72 hours, use curing mats to maintain a minimum concrete surface temperature of 70°F when air temperature is less than 70°F. Cure repaired area for at least 72 hours or until overlaid with asphalt concrete, if required, or until the area is opened to traffic. Saw and seal contraction joints in the repair area in accordance with Item 209, "Concrete Pavement." Remove repair area debris from the right of way each day.

- F. **Finishing.** Regrade and compact disturbed topsoil. Clean roadway surface after repair operations.

ITEM 234

GEOGRID FOR BASE OR EMBANKMENT REINFORCEMENT

234.1. DESCRIPTION: *Furnish and place geogrid base reinforcement in accordance with the lines and grades shown on the plans or as directed by the Engineer.*

234.2. MATERIALS: Provide geogrid in conformance with the Items and requirements stated herein.

A. Geogrid Reinforcement. Texas Department of Transportation Materials Specification DMS 6240, "Geogrid for Base/Embankment Reinforcement," of the type as shown on the plans. The sampling, testing and rejection criteria of that specification shall govern.

B. Unapproved Materials. Material substitutions for geogrids not conforming to the physical requirements of TxDOT DMS 6240 must be submitted with an alternative design proposal to the Engineer for consideration. Alternate design proposals must be accompanied by the test data from an approved laboratory showing all design and index properties in accordance with the test properties shown in TxDOT DMS 6240. If approved, the Engineer will provide written authorization. Allow a minimum of 14 days for the approval process.

234.3. CONSTRUCTION:

A. Subgrade soil shall be prepared in accordance with Specifications Item 104, "Street Excavation" and Item 107, "Embankment," prior to placement of geogrid reinforcement.

B. Geogrid reinforcement shall be rolled out parallel to the road direction at the proper elevation and alignment as shown on the construction drawings.

C. Geogrid sections shall be overlapped a minimum of one 1 foot in both directions. Placement of geogrid around corners will require cutting of geogrid product and diagonal overlapping. Unless otherwise directed by the Engineer, plastic ties shall be used at overlaps. The transverse spacing of the ties shall be 4 to 5 feet and the longitudinal tie spacing shall be 10 to 20 feet, unless otherwise approved by the Engineer.

D. The geogrid shall be pinned at the beginning of the backfilling section, but shall be left free to stretch or relieve tension throughout the remainder of the work area.

E. Contractor shall take steps to ensure that geogrid sections do not separate at overlaps during construction.

F. Base material shall be placed and compacted in accordance with Specification Item 200, "Flexible Base." This material shall be back dumped from trucks riding on top of the reinforced base material and bladed on to the grid ahead.

G. If approved by the Engineer, geogrid may be placed directly under hot-mixed asphaltic concrete base in accordance with Specification Item 205, "Hot-Mixed Asphalt Concrete Pavement." The lift thickness of base material placed directly on the geogrid shall not be greater than 6 inches compacted. This material shall be back dumped from trucks riding on top of the reinforced base material and bladed on to the grid ahead.

H. Tracked construction equipment shall not operate directly upon the geogrid. A minimum base thickness of 6 inches is required prior to operation of trucked vehicles over the geogrid.

- I. Rubber tired equipment may pass over the geogrid at slow speeds, less than 5 miles per hour if the subgrade material is capable of supporting the loads without excessive rutting or causing damage to the grid. Equipment operators shall avoid sudden braking or sharp turning.
- J. If ruts are created in the base material due to construction traffic, they shall be filled with additional base material rather than blading adjacent material into the rut.
- K. Sections of geogrid, which are damaged by construction activity, shall be repaired or replaced at the Contractor's expense. All repaired sections shall contain a minimum 3 foot overlap in all directions.
- L. Where and when necessary or appropriate for legitimate engineering considers, public health or safety, the City Engineer may require the implementation of any or all of the standard described in subsection 234.5 “ Geogrid Standards when used as Embankment Reinforcement” in the use of Geogrid for base applications.
- M. As a supplement to these design criteria, as it pertains to the use of geogrid for base and embankments, Appendix A and Appendix B are incorporated into this manual to reference the following technical reports:
 - Geosynthetic Research Institute (GRI) Standard Practice GG4(b) Standard Practice for "Determination of the Long-Term Design Strength of Flexible Geogrids", as amended on December 12, 2012; and
 - “Evaluation of Geogrids for Stabilizing Weak Pavement Subgrade” in the International Journal of Pavement Engineering, Vol. 9, No. 6, December 2008, pages 413–429.

In the design and review of construction plans by the Design Engineer and City Engineer where geogrid materials are utilized, Appendix A and Appendix B shall be utilized to determine the suitability and long term longevity of any application of geogrid materials.

234.4. TxDOT MATERIAL SPECIFICATION DMS 6240, GEOGRD FOR BASE/EMBANKMENT REINFORCEMENT”

234.4.1. Description. This Specification governs the materials, composition, quality, sampling, and testing of synthetic geogrid. Install geogrid in accordance with the lines and grades shown on the plans. Two grades of geogrid, Types 1 and 2, are specified for different loads.

234.4.2. Units of Measurements. The values given in parentheses (if provided) are not standard and may not be exact mathematical conversions. Use each system of units separately. Combining values from the two systems may result in nonconformance with the standard.

234.4.3. Definitions.

A. Geogrid—a synthetic planar structure formed by a regular network of integrally connected polymeric tensile elements with apertures designed to interlock with the surrounding fill material. Geogrid is used for the reinforcement of roadway base or embankment materials. Other uses are in accordance with the governing Specification and the plans.

B. Producer—a manufacturer of any of the products covered by this Specification or a company that sells its product under a private label agreement with a manufacturer.

234.4.4. Sampling and Testing. Sample in accordance with Tex-735-I unless otherwise specified by the Engineer. Perform testing in accordance with TxDOT Standard Tex-621-J.

234.4.5. Material Requirements.

A. General Requirements. The structure should be capable of maintaining dimensional stability

during placement and under normal construction traffic.

The geogrid should be resistant to damage during construction, including ultraviolet degradation, and it should have long-term resistance to chemical and biological degradation caused by the materials being reinforced.

B. Physical Requirements. The geogrid supplied must meet the requirements of Table 1 when sampled and tested in accordance with TxDOT standard Tex-621-J.

**Table 1
Geogrid Requirements**

Property	Type 1	Type 2
Aperture Size, mm (in.)	25–51 (1.0–2.0)	25–51 (1.0–2.0)
Percent Open Area, %	70 minimum	70 minimum
Thickness, mm (in.)		
MD ribs	0.77 (0.03) minimum	1.27 (0.05) minimum
CMD ribs	0.64 (0.025) minimum	1.15 (0.045) minimum
Junctions	1.50 (0.06) minimum	2.54 (0.10) minimum
Tensile Modulus @ 2% elongation ¹ , N/m (lb./ft.)		
MD & CMD	204,260 minimum	291,000 minimum
CMD	(14,000) minimum	(20,000) minimum
Junction Efficiency, % of rib ultimate tensile strength		
MD & CMD	90 minimum	90 minimum

1. Determined as a secant modulus without offset allowances

Note – MD and CMD do not necessarily refer to the machine (warp) and cross machine (fill) directions in the manufacturing process. They refer, for drawn products, to the more (CMD) highly drawn ribs where the aperture dimensions are unequal.

234.4.6. Packaging Requirements. Package the geogrid in rolls of the length and width specified on the plans, as directed by the Engineer. Each roll should be one continuous piece packaged in a suitable sheath, wrapper, or container to protect the geogrid from damage due to ultraviolet light, moisture, and normal storage and handling.

234.4.7. Identification. Identify each roll with a tag or label securely affixed to the outside of the roll on one end. List the following information on the label:

- unique roll number, serially designated;
- lot number or control number;
- name of producer;
- style or catalog designation of product; and
- roll width and length.

234.4.8. Basis for Rejection. If any individual sample selected at random from 100 rolls or fraction thereof fails to meet any specification requirement, that roll will be rejected. Two additional samples will be taken, one from each of two other rolls selected at random from the same 100-roll lot or fraction thereof. If either of the additional samples fails to comply with any portion of the Specification, the entire quantity of rolls represented by that sample will be rejected.

234.5 GEOGRID STANDARDS WHEN USED AS EMBANKMENT REINFORCEMENT

234.5.1 General Description This Specification includes requirements for geogrid used in reinforced slopes and Mechanically Stabilized Embankment (MSE) Wall backfill.

234.5.2 Definitions

ASTM—American Society for Testing and Materials

GRI—Geosynthetic Research Institute

234.5.3 Related References

A. Standard Specifications

The Cibolo Design and Construction Manual contains Standard Specifications for Materials, Control of Materials, and Mechanically Stabilized Embankment Retaining Walls. The design is responsible for complying with those standards, whether or not geogrid materials are proposed as a design solution. Whenever those standards conflict with the standards of this section for the use of geogrid, the conflict shall be brought to the attention of the City Engineer. Generally, the more stringent requirement shall be applicable, but due the unique nature of geogrid, the design engineer and City Engineer shall have the ability to use the lessor standard if the lessor standard will ensure the long term viability of the geogrid design solution.

B. Referenced Documents

AASHTO Task Force 27 Guidelines

U. S. Environmental Protection Agency, Method 9090—Chemical Compatibility

Association of Textile Chemists and Colorists, Method 30—Soil Burial

American Association of Textile Chemists and Colorists, Method 100—Preparation of Bacterial Broth

ASTM D 638

ASTM D 746

ASTM D 975

ASTM D 1238

ASTM D 1505

ASTM D 1525

ASTM D 2165

ASTM D 4335

ASTM D 4595

GRI—GG1

GRI—GG2-87

GRI—GG3a or GG3b

GRI—GG5

234.5.4 Submittals

Supply certification from the manufacturer showing the physical properties of the material used and conformance with the specifications of this subsection. Provide evidence from the manufacturer that the geogrid has been used successfully in installations with similar environmental and project conditions. Obtain prior approval from the City of Cibolo for all materials before use on construction.

Submit product specifications and test results to the Engineer for review and approval at least 45 days prior to intended use. Do not begin placement of geogrid until the test results have been reviewed and approved by the Engineer.

234.5.5 Materials

A. Requirements

Use geogrid that is free of defects, punctures or flaws.

1. Geogrid for Reinforced Slopes

Use geogrid materials for reinforced slope construction that consist of the following:

- Either a biaxial or uniaxial grid of polymer tensile elements manufactured into a regular network with apertures of sufficient size to allow for soil interlock.
- A commercially prepared material of high tenacity polyester, high density polyethylene (HDPE) or polypropylene that is formed by stretching, heat welding, chemical welding, knitting, weaving or combinations of these methods.

Adhere to the following additional requirements: Long Term Design Strengths

1) Use geogrid that meets the minimum long-term design strengths (TLT) in the machine direction as indicated on the plans.

2) Provide to the Engineer, in writing, the ultimate tensile strength of the grid (TULT) to verify the calculation in obtaining the long-term design loads (TLT).

These strengths are required for the Project and are determined based on the AASHTO Task Force 27 guidelines, which incorporates reduction factors to the ultimate strength of the geogrid for creep, site damage and durability.

3) Calculate the long-term design strength using the following formula:

$$TLT = \frac{TULT \times CRC}{FC \times FD}$$

Where:

TLT = Long-term design load—lb/ft (kg/m)

TULT = Geogrid ultimate tensile strength—lb/ft (kg/m)

CRC = Creep reduction coefficient

FC = Factor of safety to account for construction damage

FD = Factor of safety to account for product durability

Determine TULT

Determine the TULT based on wide strip tensile testing as noted above.

Determine Reduction Factors

Determine the reduction factors by the methods described in paragraphs a - e as follows:

1) Creep

a) Provide evidence from the manufacturer that the geogrid has been tested in laboratory creep tests according to the following criteria:

- Conducted for a minimum duration of 10,000 hours
- Tests were made for a range of load levels, including loads that the geogrid will be subjected to on the Project.

b) Ensure these tests are conducted as specified in this subsection.

c) Extrapolate the results extrapolated to a minimum design life of 75 years.

d) Determine the tension level at which the total strain of the geogrid is not expected to exceed 10% within the design life of 75 years (designated Tw).

e) Calculate the creep reduction factor as follows:

$$CRC = \frac{Tw}{TULT}$$

In the absence of test data, use the following creep reduction factors for different polymers:

Polymer Type Creep Reduction Coefficient

Polyester	0.40
Polypropylene	0.20
Polyamide	0.35
Polyethylene	0.20

2) Construction Damage

- a) Provide evidence from the manufacturer that the geogrid has been subjected to full scale construction damage tests using fill materials and construction procedures which are representative of those on the Project.
- b) Excavate and test the grid according to the requirements listed above.
- c) Calculate the construction damage factor of safety using the following formula:

$$FC = \frac{TULT}{TC}$$

Where:

FC = The construction damage factor

TC = The ultimate strength of the excavated grid that has been subjected to construction damage tests.

TULT = Geogrid ultimate tensile strength—lb/ft (kg/m)

- d) If construction damage tests have been made, but with fills or construction procedures other than those represented on the Project, use a minimum value of FC of 1.25. Use a lower value of FC only if substantiated with damage tests using fills and construction procedures specific to the Project.
- e) In the absence of any construction damage tests, use a FC value of 3.0.

3) Product Durability

a) Provide evidence from the manufacturer that the geogrid has been subjected to a series of durability tests to examine the effects of chemical and biological exposure on the grid, as described in the AASHTO Task Force 27 report.

b) Include the following in the durability studies:

- Effect on short-term and long-term mechanical properties.
- Changes to the following:
 - Reinforcement microstructure
 - Dimensions
 - Mass
 - Oxidation
 - Environmental stress cracking
 - Hydrolysis
 - Temperature
 - Plasticization
 - Surface Micrology
 - Variations in the infrared spectrum analysis.

- A full investigation into the synergetic effects of different environments, particularly temperature. Subject the reinforcement to a working stress during the environmental test.
- c) Ensure that geogrid used in the Work has been subjected to the environmental conditioning as outlined by the following, as a minimum:
- U.S. Environmental Protection Agency, Method 9090 – Chemical Compatibility.
 - Association of Textile Chemists and Colorists, Method 30 – Soil Burial.
 - American Association of Textile Chemists and Colorists, Method 100 – Preparation of Bacterial Broth.
- d) Investigate the full range of soil environments to which the reinforcements may be potentially exposed and shall include as a minimum:
- pH in the range of 2, 4, 8, 12 – ASTM-D-2165
 - Diesel oil – ASTM-D-975
 - Fungi and Bacteria
 - UV exposure 500 hrs – ASTM-O-4335
 - Solvents and agents that are site specific.

In the performance of this testing the conditioning temperature is laboratory standard plus 1.5 times laboratory standard for the pH environments. When no conditioning time period is given, use 30 days. Extrapolate results from short-term tests to the required design life of 75 years.

After the geogrid is subjected to these conditions, test the geogrid according to requirements of this section and calculate the durability factor of safety by the following formula:

$$FD = \frac{TULT}{TD}$$

Where:

TD= The ultimate strength of the geogrid subjected to product durability tests.

The minimum allowable value of FD is 1.10. In the absence of any geogrid durability tests, use a Durability Factor (FD) of 2.0.

4) Pullout Resistance:

- a) Provide evidence from the manufacturer that the geogrid has been subjected to full-scale pullout tests using backfill materials representative of those on the Project, as described in the AASHTO Task Force 27 report.
- b) Base pullout resistance for design on a maximum of elongation of the embedded geogrid of ¾ in (19 mm) as measured at the leading edge of the compressive zone within the soil mass and not the ultimate pullout capacity.
- c) Where insufficient data exists to evaluate the pullout resistance of geogrid as a function of soil type, conduct pullout tests on a project specific basis until the engineering behavior of the soil-reinforcement system is clearly defined.
- d) Perform pullout using vertical stress variations (Sv) and reinforcement element configurations simulating actual project conditions.
- e) Perform pullout tests according to Subsection 809.2.02 on samples with a minimum embedded length of 2 ft (600 mm). Perform the tests on samples with a minimum width of 1 foot (300 mm), or a width equal to a 4 longitudinal grid element, whichever is greater. Conduct the tests at 70° F (plus/minus 4° F) at constant strain rates of 0.02 in (0.5mm) per minute.

Evaluate the pullout resistance by the following relation:

$$T_p = (2 \tan P) \times S_v \times L_s \times f_d$$

Where:

T_p = Ultimate pullout capacity of tensile reinforcement—lb/ft (kg/m)

S_v = Vertical stress—lb/ft² (kg/m²)

L_s = Total length of geogrid beyond failure plane—ft (m)

P = Internal angle of friction of select backfill

f_d = Equivalent coefficient of direct sliding derived from pullout tests

The equivalent coefficient of direct sliding, f_d , may be related to the open area of the grid. In the absence of product specific data tested with site-specific granular backfill, estimate the f_d from the following preliminary analysis:

<u>% Open Area of Grid</u>	<u>Direct Sliding</u>
80% or more	0.5
51 to 79%	0.7
50% or less	0.6

Ensure the pullout resistance, T_p , meets the following minimum strength requirement:

$$T_p = FPO \times TLT \text{ with a displacement less than or equal to } \frac{3}{4} \text{ in (19 mm)}$$

Where:

FPO = Factor of safety against pullout, equal to 1.5

TLT = Long-term design load—lb/ft (kg/m)

5) Junction Strength:

- Ensure that the summation of the shear strength of the joints occurring in a 12 in (300 mm) length of the grid sample is greater than the ultimate tensile strength of the element to which they are attached.
- If this condition is not met, reduce the allowable reinforcement tension, T_w , by the ratio of the shear strengths to the ultimate strength.
- Determine the ultimate tensile strength according to the standards of this subsection and translate it into an ultimate strength per element by dividing the number of elements per foot (meter) of width.
- Measure the junction strength according to the standards of this subsection.

2. MSE Wall Backfill Stabilizing Geogrid (SR 3)

Use geogrid materials for MSE wall construction that meets the following requirements:

- Is a biaxial grid of polymer tensile elements manufactured into a regular network with apertures of sufficient size to allow for soil interlock.
- Is a commercially prepared material of copolymerized high density polyethylene (HDPE) that is formed by stretching, heat welding, chemical welding, or combinations of these methods.
- Has the following physical properties:

Physical Properties

<u>Property</u>	<u>Requirement</u>
Melt Index	0.00176 - 0.00846 oz./10 min. (0.05 - 0.24 grams/10 min.)
Density	59.0 – 59.6 pcf (0.945 - 0.955 grams/cc)
Tensile Strength	500 ksf (24 000 kPa) minimum
Ultimate Elongation	500% min.
Brittleness	-174 ° F maximum

Vicat Softening Point	260° F minimum
Chemical Resistance	Resistant to all natural occurring alkaline and acidic soil conditions
Biological Resistance	Resistant to attack by bacteria and fungi

- Has the following structural and mechanical properties:

MSE Wall Geogrid – Structural and Mechanical Properties

<u>Property</u>	<u>Requirement</u>
Roll Length	100 feet
Roll Width	3 feet or 4.5 feet
Roll Weight	82 pounds (3' roll) or 114 pounds (4.5' roll)
Grid Pitch	0.6" x 4"
Color	Black
Ultimate Tensile Strength	7.47 kips/foot
Extension @ Ult. Tensile Strength	17.0% maximum
Extension @ Design Load (0.4 Ult.)	3.0% maximum
Modulus in Tension	9,000 ksi
Thermal Stability	Stable over a range of -60° F to 174° F

Note- Tests are based 10 single rib samples extended at a constant rate of 1 inch at a temperature of 68° F (plus/minus 4° F)

B. Fabrication

The blocks and rolls for projects using geogrid shall be fabricated at the same plant. No change in cementitious content or source is allowed. The Engineer, with the consent of the City Engineer may allow blocks or rolls to be cast at another plant only if provided with a written request and mix design documentation that demonstrates that the same cementitious content, sources and fabrication process.

C. Acceptance

Test Geogrid to the following minimum standards:

<u>TEST PROPERTY</u>	<u>TEST METHOD</u>
• Reinforced Slopes	
Tensile Strength- Wide Width	ASTM D 4595
Tensile Strength – Single Rib Strand	GRI – GG1
Junction Strength	GRI – GG2-87
Tensile Creep Testing	GRI – GG3a or GG3b
Geogrid Pullout	GRI-GG5
• MSE Wall Backfill Stabilizing Geogrid (SR 3)	
Melt Index	ASTM D 1238
Density	ASTM D 1505
Tensile Strength	ASTM D 638
Ultimate Elongation	ASTM D 638
Vicat Softening Point	ASTM D 1525
Brittleness	ASTM D 746

D. Materials Warranty

Geogrid shall be installed in accordance with all manufacturer recommendations. The developer and his engineer and contractor is responsible to report to the City Engineer immediately whenever the standards and criteria of this design criteria conflicts with the installation recommendations of the manufacturer and is responsible to coordinate a satisfactory resolution to the issue to satisfy the criteria contained herein and maintain the manufacturer's warranty by the proper installation of the geogrid product.

234.5.6 Delivery, Storage and Handling

During shipment and storage, protect the grid from mud, dirt, dust, debris and exposure to ultraviolet light, including sunlight.

ITEM 236

FULL DEPTH RECLAMATION

236.1. DESCRIPTION: *Mix and compact emulsion, additives, water, and base with or without asphalt concrete pavement, in the roadway.*

236.2. 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 TxDOT standard laboratory test procedure Tex-100-E for material definitions.

A. Emulsion. Provide an asphalt-emulsion that meets the requirements of Table 2.

B. Flexible Base (“Add Rock”). Furnish base material that meets the requirements of Item 200, “Flexible Base,” for the type and grade shown on the plans, before the addition of emulsion.

C. Additive. Determine the amount and type of additive, if any, during the mix design. When an additive is required, the total amount in the mix will not exceed 1.0 % by weight of material.

1. Lime. When lime is required, furnish lime that meets the requirements for TxDOT’s DMS 6350, “Lime and Lime Slurry,” and DMS-6330, “Lime Sources Prequalification of Hydrated Lime and Quicklime.” Use hydrated lime or commercial lime slurry, as shown on the plans. Dry placement shall not be used unless written approval is granted by the Engineer.

2. Cement. When cement is required, furnish hydraulic cement that meets the requirements of TxDOT’s DMS-4600, “Hydraulic Cement,” and their Hydraulic Cement Quality Monitoring Program (HCQMP). Sources not on the HCQMP will require testing and approval before use.

D. Mix Design. Submit a mix design to the Engineer for approval, before the start of the project. Include the optimum moisture content, maximum dry density, percent additive, percent “add rock”, percent existing material, percent moisture content at which to add emulsion, and optimum percent asphalt emulsion required to meet the mixture requirements in Table 1. Prepare specimens for all tests in accordance with TxDOT standard laboratory test procedure Tex-241-F. Perform additional mix designs based on existing material variability, as directed by the Engineer. Any cost associated with taking samples from the existing base, traffic control during sampling procedures, equipment used for sampling, patching the existing pavement, and providing the mix design shall be included with the unit prices for item 236, “Full Depth Reclamation.”

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

Table 1
Laboratory Mixture Design Properties¹

Property	Procedure ²	Criteria
Superpave gyratory compaction, gyrations	Tex-241-F ³	30
Min. indirect tensile strength (ITS), minimum psi	Tex-226-F ⁴	50
Resilient modulus, minimum	AASHTO T 307	300,000

1. It is recommended to sample at least 3-feet by 3-feet pits the entire existing pavement depth (being careful not to excavate into the subgrade) or an adequate volume for the mix design. Sample the existing pavement at an 800-foot interval and not less than 2 per roadway. Based on roadway variability, more than one design may be required.

2. TxDOT standard laboratory test procedure, unless otherwise noted.

3. Equipment requirements are 1.25° angle, 87 psi.

4. Indirect tensile strength specimens will be cured 72 hours at 104°F before testing.

Table 2
Emulsified Asphalt Properties

Test	Method	Min	Max
Residue from distillation, %	ASTM D 244 ¹	63	-
Oil distillate by distillation, %	ASTM D 244 ¹	-	0.5
Sieve Test, %	ASTM D 244 ¹	-	0.1
Penetration ² , 77°F, dmm	ASTM D 5	-25%	+25%

1. Modified ASTM D244 procedure – distillation temperature of 350 °F with a 20 minute hold. The ASTM D244 vacuum distillation procedure may be substituted once the maximum oil distillate is satisfied.

2. To be determined from the mix design prior to emulsion manufacture for project. Penetration range will be reported on the submitted mix design.

236.3. 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 TxDOT Item 216, “Proof Rolling,” when required.

Provide a self-propelled mixer capable of fully mixing the existing road to the depth required, incorporate the asphalt emulsion and water, and mix the materials to produce a homogeneous material. Provide a mixer with a minimum power of 400 HP. Provide a machine capable of mixing not less than 8 feet wide and up to 12 inches deep in each pass. The mixer must contain a system for adding asphalt emulsion with a full width spray bar consisting of a positive displacement pump interlocked to the machine speed so that the amount of emulsion being added is automatically adjusted with changes in machine speed. The emulsion injection system will be capable of incorporating up to 7 gallons per square yard of emulsion. Provide individual valves on the emulsion injection system spray bar that are capable of being turned off as necessary to minimize emulsion overlap on subsequent passes.

236.4. 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.

A. Preshaping. Shape the existing material in accordance with applicable bid items to conform to typical sections shown on the plans and as directed before the addition of asphalt-emulsion. Incorporate water and add rock during this operation, if needed. Compact the material to support equipment and/or traffic, and to provide depth control during mixing.

B. Mixing. Moisture content before addition of the emulsion and additive (if required by the mix design) shall be within 1 percent from the mix design recommendation and as measured in Section 236.5, “Quality Control;” aerate if too wet and add water if too dry. Add emulsion and additives, if required, at the percentage(s) determined in Section 236.2.D, “Mix Design.” Monitor the required depth of mixing regularly.

Complete the entire operation of mixing the existing road, incorporating add rock, additive, water, and asphalt emulsion in one pass. Ensure that each adjacent pass of the mixer overlaps the previous pass by a minimum of 6 inches. Use multiple passes if the quality control requirements specified in Section 236.5, “Quality Control” are not met. If an additional pass of the mixer significantly improves dispersion of the emulsion, use this additional pass for the entire project.

After mixing, the Engineer will sample the mixture at roadway moisture and test in accordance with TxDOT standard laboratory test procedure Tex-101-E, Part III, to determine compliance with the following gradation requirements:

Sieve Size	Percent Passing
1-3/4 in.	97-100
3/4 in.	85

C. Application of Additive. Uniformly apply additive in advance of the mixer. Minimize dust and scattering of additives by wind. Do not apply additives when wind conditions, in the opinion of the Engineer, cause blowing additive to become dangerous to traffic or objectionable to adjacent property owners.

- 1. Lime.** Uniformly apply lime using slurry placement as shown on the plans, or as directed. Dry placement of lime is not allowed unless otherwise approved by the Engineer. Add lime at the percentage determined in the 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.

- a. Slurry Placement.** Provide slurry free of objectionable materials, at or above the approved minimum dry solids content, and with a uniform consistency that will allow ease of handling and uniform application. Deliver commercial lime slurry to the jobsite or prepare lime slurry at the jobsite or other approved location by using hydrated lime as specified.

Distribute slurry uniformly by making successive passes over a measured section of roadway until the specified lime content is reached.

- b. Dry Placement.** Dry placement is not allowed unless approved by the Engineer. If used, when necessary, sprinkle in accordance with TxDOT Item 204, "Sprinkling." Distribute the required quantity of hydrated lime with approved equipment. Only hydrated lime may be distributed by bag. Do not use a motor grader to spread hydrated lime.
- 2. Cement.** Uniformly apply cement using slurry placement unless otherwise shown on the plans or approved by the Engineer. Add cement at the percentage determined in the mix design. Apply cement only on an area where mixing, compacting, and finishing can be completed during the same working day. Distribute the required quantity of dry cement with approved equipment.
 - 3. Emulsion.** Uniformly apply emulsion as specified in Section 236.4.B, "Mixing." Add emulsion at the percentage determined in Section 236.2.D, "Mix Design." Apply emulsion only on an area where mixing and compaction can be completed during the same working day.

Suspend emulsion application if the weather forecast calls for freezing temperatures within 7 days after incorporation of the emulsion. Suspend application when the Engineer determines that weather conditions are unsuitable.

D. Compaction. Compact the mixture using density control, unless otherwise shown on the plans. Multiple lifts are permitted when shown on the plans or approved.

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.

Perform initial compaction using a heavy tamping roller applying high amplitude and low frequency. Maintain the heavy tamping roller within 500 feet of the mixer at all times. Continue rolling until the heavy tamping roller “walks out” of the material. Walking out for the heavy tamping roller is defined as light being evident between all of the pads at the material–heavy tamping roller drum interface.

After the completion of heavy tamping rolling, remove remaining tamping marks. Cut no deeper than the depth of the tamping marks. Achieve desired slope and shape to the lines and grades shown in the plans. Perform final surface shaping on the same day as the asphalt emulsion is incorporated.

Use a vibratory roller and pneumatic roller to compact the bladed material. Do not finish-roll in vibratory mode. If necessary, use a light spray of water to aid in final compaction density and appearance.

Rework material that fails to meet or that loses required moisture, density, stability, or finish within 24 hours of completion of compaction. Add additional emulsion and additives at 100% of the percentages determined during mix design. Reworking includes loosening, adding material or removing unacceptable material if necessary, mixing as directed, compacting, and finishing. Continue work until specification requirements are met. Perform the work at no additional expense to the City.

When an area fails to meet or loses required moisture, density, stability, or finish more than 24-hours after completion of compaction and before the next course is placed or the project is accepted, remove the unacceptable material and replace with new material that meets the mix design requirements. Compact and finish until specification requirements are met. Perform the work at no additional expense to the City.

- 1. Ordinary Compaction.** Roll with approved compaction equipment, as directed. Correct irregularities, depressions, and weak spots immediately by scarifying the areas affected, adding or removing treated material as required, reshaping, and recompacting.
- 2. Density Control.** The Engineer will determine roadway density of completed sections in accordance with TxDOT standard laboratory test procedure 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.

Compact the bottom course to at least 97% of the maximum density determined in accordance with TxDOT standard laboratory test procedure Tex-113-E, unless otherwise shown on the plans. Compact subsequent courses treated under this Item to at least 97% of the maximum density determined in accordance with TxDOT standard laboratory test procedure Tex-113-E, unless otherwise shown on the plans.

- E. 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. Do not allow equipment or traffic on the finished course during curing, unless otherwise approved. The Engineer may allow traffic on the finished course during curing if proof rolling indicates adequate stability. Proof roll in accordance with TxDOT Item 216, “Proof Rolling.” If deformation occurs, do not allow traffic to return to the finished section until the mixed material is firm enough to accommodate traffic without deformation. Apply seals or additional courses within 14 calendar days of final compaction.

When the plans show no specific detour, the Contractor will provide one-way traffic control until proof rolling permits the return of normal traffic to the compacted material.

236.5. Quality Control. To ensure quality control (QC) of the process and the completed base, the Engineer will be provided the sampling frequencies listed below.

- A. Asphalt Emulsion.** A representative from the asphalt emulsion supplier will check the mixing and curing properties at the beginning of the project, and will make recommendations for design changes to the Engineer.
- B. Moisture Content.** Use TxDOT standard laboratory test procedure Tex-103-E to check moisture content before addition of emulsion. Check the moisture content on the same day emulsion is applied. If rain has occurred after testing and before emulsion addition, recheck the moisture content. Adjust by moisture addition (water truck) or aeration if the average moisture content is not within 1% of the mix design recommendation. Recheck the moisture content if manipulation has occurred.
- C. Emulsion Content.** Apply the amount of asphalt emulsion recommended in the mix design. The Engineer must approve changes in asphalt emulsion content or supplier. Check the percentage of emulsion added using meter readings or truck weigh tickets, the quantity of material reclaimed (depth, width, and length) and estimated in-place density determined by TxDOT standard laboratory test procedure Tex-113-E (mix design or field check) or nuclear density gauge. Determine emulsion content on the first day of processing during the first emulsion transport. Adjust equipment calibration if necessary. Check emulsion content again if adjustments are made. Determine subsequent emulsion content as directed by the Engineer, but not less than once per day.
- D. Density.** Obtain samples to the full depth of reclamation before rolling and store in a sealed container for no longer than 2 hours. Compact in accordance with TxDOT standard laboratory test procedure Tex-113-E and adjust mixing and compaction operations to achieve maximum dry density established in the mix design.

ITEM 238
RUBBERIZED EMULSION AGGREGATE
SLURRY WITH POLYMER (REAS)

238.1. DESCRIPTION: *This Item shall govern for the installation of a mixture of rubberized polymer modified emulsion asphalt (RPME) consisting of proportioned and mixed ground tire rubber and polymer, mineral aggregate, and water properly proportioned, mixed, and spread on an asphalt prepared underlying course or existing wearing course in accordance with these specifications and shall conform to the dimensions shown on the plans or as directed by the Engineer. The slurry, when cured, shall bare a homogeneous appearance, fill all cracks, and adhere firmly to the adjacent surface, and have a skid resistance texture.*

Methods, materials, or any specific reference included in this specification shall conform to the following specifications:

- AASHTO M 17
- ASTM C 88
- ASTM C 117
- ASTM C 131
- ASTM C 136
- ASTM D 242
- ASTM D 2419

238.2. MATERIALS:

A. Aggregate. The aggregate shall consist of sound and durable manufactured sand, slag, crusher fines, crushed stone, or a combination thereof. The aggregate shall be clean and free from vegetable matter, dirt, and other deleterious substances. The aggregate shall have a sand equivalent of not less than 45 percent when tested in accordance with ASTM D 2419. The aggregate shall show a loss of not more than 35 percent when tested in accordance with ASTM C 131. The sodium sulfate soundness loss shall not exceed 12 percent, or the magnesium soundness loss shall not exceed 20 percent after 5 cycles when tested in accordance with ASTM C 88. Aggregate shall be 100 percent crushed. The combined aggregate shall conform to the gradation shown in Table 1 when tested in accordance with ASTM C 136 and ASTM C 117.

The job mix formula (mix design) shall be run using aggregate within the gradation band shown in Table 1. Once the mix design has been submitted and approved, the aggregate used on the project shall not vary by more than the tolerances shown in Table 2. At no time shall the aggregate used go out of the gradation bands in Table 1.

The aggregate will be accepted at the job location or stockpile. The stockpile will be accepted based on five gradation tests samples in accordance with ASTM D 75. If the average of the five tests is within the gradation tolerances, then the materials will be accepted. If the tests show the materials to be out of tolerance, the Contractor will be given the choice either to remove the material or blend other aggregates with the stockpile material to bring it into specification. Materials used in blending shall meet the quality tests before blending and shall be blended in a manner to produce a consistent gradation. This may require a new mix design.

Table 1
Aggregate Gradation Requirements
% by Weight Passing Sieve

Sieve Size	Type II
3/8"	100
#4	90 - 100
#8	65 - 90
#16	45 - 70
#30	30 - 50
#50	18 - 30
#100	10 - 21
#200	5 - 15
Residual RPME ¹ content by percent dry weight of aggregate	14 - 17

¹RPME – Rubberized polymer modified emulsion

Screening shall be required at the project stockpile site if there are any problems created by having oversize materials in the mix.

Precautions shall be taken to prevent segregation of the aggregate in storing and handling. The stockpile shall be kept in areas that drain readily.

- B. Aggregate Tolerance.** Once the mix design has been accepted, the aggregate gradation used on the project may vary from the aggregate gradation used in the mix design on each sieve by the percentages shown in Table 2. If the project aggregate fails to remain within this tolerance, the Engineer at the expense of the Contractor will require a new mix design.

Table 2
Aggregate Gradation Tolerances
% by Weight Passing Sieve

Sieve Size	Type II
3/8"	± 5%
#4	± 5%
#8	± 5%
#16	± 5%
#30	± 5%
#50	± 4%
#100	± 3%
#200	± 2%
Residual RPME ¹ content by percent dry weight of aggregate	± 1%

¹RPME – Rubberized polymer modified emulsion

- C. Mineral Filler.** If mineral filler, in addition to that naturally present in the aggregate, is necessary, it shall meet the requirements of ASTM D 242 and shall be used in the amounts required by the mix design. The mineral filler shall be considered as part of the aggregate.

- D. Rubberized Polymer Modified Emulsion (RPME).** The RPME shall be a slow-set or a quick-set type of emulsion as determined by the Engineer. RPME shall contain asphalt, ground tire rubber and polymer modifiers. The RPME shall conform to the following quality requirements:

Viscosity, 25°C (77°F), Brookfield, Model RVT #6 Spindle @ 10 RPM (Centipoises)	2,500 min. 20,000 max.
Residue by Evaporation % ASTM D 244	50 min.
Sieve Test % retained on No. 20 screen ASTM D 244	2.0 max. ²
Weight per Liter (Gallons)	8.33 lbs/gal min. 8.75 lbs/gal max.
Penetration of Residue, 25°C (77°F), 100 g, 5 sec. ASTM D 5	20 min. 40 max.
Percent Residue Soluble in Trichloroethylene ASTM D 2042	75 min.

²Sieve test of original emulsion is 0.10 max.

- E. Ground Tire Rubber.** The material shall be granulated scrap tire rubber free from fabric wires and other contaminants. Rubber shall be dry and free flowing. Calcium carbonate or talc may be added to a maximum of 4 percent by weight of rubber to prevent rubber particles from sticking together. The rubber shall have a specific gravity between 1.15 and 1.20. One hundred percent of the rubberized material shall pass a No. 16 sieve, 95 percent shall pass a No. 20 sieve, and a maximum of 2 percent shall pass a No. 200 sieve. The RPME shall contain between 0.55 lbs/gal and 0.65 lbs/gal of crumb rubber.
- F. Polymer Modifier.** Polymer modifier shall be latex, which is added at a minimum of 2 percent polymer solids by weight of the RPME.
- G. Water.** All water used in making the slurry shall be potable and free from harmful soluble salts and chemicals.

238.3. COMPOSITION: The Rubberized Emulsion Aggregate Slurry with Polymer shall consist of a mixture of RPME, mineral aggregate, and water.

- A. Job Mix Formula.** No slurry seal for payment shall be placed until the Engineer has approved a mix design. The mix design shall be developed by a laboratory with experience in designing slurry seal mixes and a signed copy shall be submitted in writing by the Contractor to the Engineer at least 10 days prior to the start of operations.

The laboratory report (mix design) shall indicate the proportions of aggregates, mineral filler (min. and max.), water (min. and max.) and RPME based on the dry aggregate weight. It shall also report the quantitative effects of moisture content on the unit weight of the aggregate (bulking effects) and shall report the particle charge of the RPME (anionic or cationic). The mix design shall be in effect until modified in writing by the Engineer. Should a change in sources of materials be made, a new mix design shall be established before the new material is used.

The main items of design in Rubberized Emulsion Slurry Seal with Polymer are aggregate gradation, RPME content and consistency of the mixture. The aggregates, RPME, and water

should form a creamy-textured slurry that, when spread, will flow ahead of the strike-off squeegee. Proportions shall be based on the mix design.

The Contractor shall submit to the Engineer for approval a complete mix design on the materials proposed for use, prepared and certified by an approved laboratory. Compatibility of the aggregate, emulsion, mineral filler, and other additives shall be verified by the mix design. The mix design shall be made with the same aggregate and RPME that the Contractor will provide on the project. At a minimum the required tests and values needed are as follows:

Test	Description	Specification
ISSA TB-100	Wet Track Abrasion Loss One Hour Soak	50 g/ftz max.

- B. Application Rate.** Unless otherwise specified, the slurry seal shall be applied at the application rates shown in Table 3 for that gradation of material used.

Table 3
Application Rates

Pounds of mixture per square yard	10 - 15
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The rate of application shall not vary more than ± 2 pounds per square yard.

- C. Test Sections.** Test sections shall be placed prior to the start of the slurry seal work in the presence of the Engineer. The test area will be designated by the Engineer and will be located on the existing pavement. The test section shall be made after each machine has been calibrated. Samples of the slurry seal shall be taken and the mix consistency and proportions verified. The rate of application will also be verified. If the test section should prove to be unsatisfactory, the necessary adjustments to the materials, equipment and/or application rates shall be made. Additional test sections, as required, shall be conducted and evaluated for conformance to the specifications. When the test sections do not conform to specification requirements, the treatment shall be removed, and replaced at the contractor's expense. Test section in conformance with the specification will be paid for in accordance with "Basis of Payment" section. Full production shall not begin without the Engineer's approval.

238.4. EQUIPMENT: All methods employed in performing the work and all equipment, tools, and machinery used for handling the material and executing any part of the work shall be subject to the approval of the Engineer before the work is started, and whenever found unsatisfactory they shall be changed and improved as required. All equipment, tool, machinery and containers used must be kept clean and maintained in a satisfactory condition. The Contractor shall furnish all equipment, tools, and machinery necessary for the performance of this work.

- A. Slurry Mixing Equipment.** The machine shall be specifically designed and manufactured to lay slurry seal. The material shall be mixed by a self-propelled slurry mixing machine of either truck mounted or continuous run design. Either type machine shall be able to accurately deliver and proportion the aggregate, RPME, mineral filler, and water to a revolving mixer and discharge the mixed product on a continuous flow basis. The machine shall have sufficient storage capacity for materials to maintain an adequate supply to the proportioning controls.

If continuous run equipment is used, the machine shall be equipped to allow the operator to have full control of the forward and reverse speed of the machine during application of the slurry seal, with a self-loading device, with opposite side driver stations, all part of original equipment manufacturer design.

The mixing unit of the mixing chamber shall be capable of thoroughly blending all

ingredients. No excessive mixing shall be permitted. The mixing machine shall be equipped with a fines feeder that provides an accurate metering device or method to introduce a predetermined proportion of mineral filler into the mixer at the same time and location that the aggregate is fed into the mixer.

The mixing machine shall be equipped with a water pressure system and fog-type spray bar adequate for complete fogging of the surface with an application of 0.05 to 0.10 gallon per square yard preceding the spreading equipment.

Sufficient machine storage capacity to mix properly and apply a minimum of 5 tons of the slurry seal shall be provided. Proportioning devices shall be calibrated prior to placing the slurry seal.

- B. Slurry Spreading Equipment.** The mixture shall be spread uniformly by means of a conventional surfacing spreader box attached to the mixer and equipped to agitate and spread the material evenly throughout the box. A front seal shall be provided to insure no loss of the mixture at the surface contact point. The rear seal shall act as the final strike-off and shall be adjustable. The spreader box and rear strike-off shall be so designed and operated that a uniform consistency is achieved to produce a free flow of material to the rear strike-off. The spreader box shall have suitable means provided to side shift the box to compensate for variations in the pavement geometry. A burlap drag or other approved screed may be attached to the rear of the spreader box to provide a uniform mat.
- C. Auxiliary Equipment.** Other tools or equipment such as brushes, hand squeegees, hose equipment, tank trucks, water distributors and flushers, power blowers, barricades, etc., shall be provided as required.
- D. Tack Coat and Distributor.** Normally a tack coat is not required unless the surface to be covered is extremely dry and raveled or is concrete or brick. If required, the tack coat should consist of one part emulsified asphalt and three parts water. The Engineer shall determine the type of asphalt emulsion used for the tack coat. Pressure distributors used for application of the diluted asphalt emulsion tack coat shall be self-propelled, equipped with pneumatic tires, and capable of uniformly applying 0.05 to 0.15 gallon per square yard of the diluted emulsion over the required width of application. Distributors shall be equipped with tachometers, pressure gages, and volume-measuring devices. The tack coat shall be applied at least 2 hours before the slurry seal but within the same day.
- E. Equipment Calibration.** Each slurry seal-mixing unit to be used on the project shall be calibrated in the presence of the Engineer prior to construction. The Engineer may accept previous calibration documentation covering the exact materials to be used provided they were made during the calendar year. The documentation shall include an individual calibration of each material at various settings, which can be related to the machine's metering devices. No machine will be allowed to work on the project until the calibration has been completed and/or accepted.

238.5. CONSTRUCTION:

- A. Weather Limitations.** The REAS shall not be applied if either the pavement or air temperature is 60°F and falling but may be applied when both pavement and air temperatures are 55°F and rising. No REAS shall be applied when there is danger that the finished product will freeze before 24 hours. The mixture shall not be applied when weather conditions prolong opening to traffic beyond a reasonable time.
- B. Application of REAS.** The surface shall be pre-wet by fogging ahead of the slurry spreader box. Water used in pre-wetting the surface shall be applied at such a rate that the entire

surface is damp with no apparent flowing water in front of the slurry spreader box. The slurry mixture shall be of the desired consistency when deposited on the surface, and no additional elements shall be added. Total time of mixing shall not exceed 2 minutes. A sufficient amount of slurry shall be carried in all parts of the spreader box at all times so that complete coverage of all surface voids and cracks is obtained. Care shall be taken not to overload the spreader box, which shall be towed at a slow and uniform rate not to exceed 5 miles per hour. No lumping, balling, or unmixed aggregate shall be permitted. No segregation of the emulsion and fines from the coarse aggregate will be permitted. If the coarse aggregate settles to the bottom of the mix, the slurry shall be removed from the pavement surface. A sufficient amount of slurry shall be fed into the box to keep a full supply against the full width of the spreader box. The mixture shall not be permitted to overflow the sides of the spreader box. No breaking of the emulsion will be allowed in the spreader box. The finished surface shall have no more than four (4) tear or drag marks greater than ½ inch wide and 4 inches long in any 12 foot by 22 foot section. It shall have no tear or drag marks greater than 1 inch wide and 3 inches long. The finished surface shall have no transverse ripples of ¼ inch or more in depth, as measured with a 10 foot straight edge laid upon the surface.

- C. Preparation of Existing Surface.** Prior to placing the tack coat and/or REAS, unsatisfactory areas shall be repaired and the surface shall be cleaned of dust, dirt, or other loose foreign matter, grease, oil, excessive rubber accumulation, or any type of objectionable surface film. Any standard cleaning method will be acceptable except that water flushing will not be permitted in areas where considerable cracks are present in the pavement surface. Any painted stripes or markings on the surface of the pavement to be treated shall be removed.

Cracks wider than ¼ inch shall be cleaned with compressed air, and sealed with a compatible crack sealer prior to applying the slurry seal. Cracks wider than ¾ inch should be pre-filled and sealed with the slurry mixture prior to surfacing. Cracks that show evidence of vegetation shall be cleaned and treated with an approved herbicide. Crack sealing and herbicide treatment are subsidiary to this item.

Adjacent lanes shall be lapped at the edges a minimum of 2 inches with a maximum of 4 inches to provide complete sealing at the overlap. Construction longitudinal and transverse joints shall be neat and uniform without buildup, uncovered areas, or unsightly appearance. All joints shall have no more than ¼ inch difference in elevation when measured across with a 10-foot straight edge.

The fresh slurry seal application shall be protected by barricades and markers and permitted to dry for 4 to 24 hours, depending on weather conditions. Any damage to uncured slurry shall be repaired at the expense of the Contractor.

In areas where the spreader box cannot be used, the slurry shall be applied by means of a hand squeegee. Upon completion of the work, the seal coat shall have no holes, bare spots, or cracks through which liquids or foreign matter could penetrate to the underlying pavement.

The cured slurry shall have a homogeneous appearance, fill all cracks, adhere firmly to the surface and have skid resistant texture satisfactory to the Engineer. All wasted and unused material and all debris shall be removed from the site prior to final acceptance. Barricades to protect the slurry seal during curing shall not be measured and paid for separately, but will be considered as subsidiary to slurry seal item.

Upon completion of the project, the Contractor shall sweep the finished surface with a conventional power rotary broom, to remove any potential loose material from the surface. The material removed by sweeping shall be disposed of in a manner satisfactory to the Engineer.

F. Rubberized Polymer Modified Emulsion (Contractor's Responsibility). Samples of the RPME that the Contractor proposes to use, together with a statement as to its source, shall be submitted, and approval shall be obtained before using such material. The Contractor shall submit to the Engineer a manufacturer's certified report for each consignment of the RPME. The manufacturer's certified report shall not be interpreted as a basis for final acceptance. All such reports shall be subject to verification by testing samples of the RPME as received for use on the project.

ITEM 239 MICRO-SURFACING

239.1. DESCRIPTION: *This specification shall govern the application of a micro-surfacing product, which shall consist of a mixture of polymer-modified asphalt emulsion, mineral aggregate, mineral filler, water, and other additives, properly proportioned, mixed and spread on a paved surface. The mix shall be capable of being spread in variable thick cross-sections (wedges, ruts, scratch courses, and surfaces) which, after curing and initial traffic consolidation, resist compaction throughout the entire design tolerance range of bitumen content and variable thickness to be encountered. The end product shall maintain a skid-resistant surface in variable thick sections throughout the service life.*

239.2. MATERIALS: Provide materials in conformance with the following Items and requirements:

A. Cationic Polymer-Modified Asphalt Emulsion. Provide CSS-1P in accordance with TxDOT Item 300, Section 2.D. “Emulsified Asphalt.”

B. Mineral Aggregate. Provide a crushed aggregate from a single source meeting the requirements of Table 1 and Table 2. Unless otherwise shown on the plans, furnish aggregate with a minimum “B” Surface Aggregate Classification (SAC) as defined in TxDOT’s Bituminous Rated Source Quality Catalog (BRSQC). Include the amount of mineral filler added to the mix in determining the total minus No. 200 aggregate fraction.

**Table 1
Aggregate Gradation Requirements
Tex-200-F, Part II (Washed)
Cumulative % Retained**

Sieve Size	Type I	Type II
1/2”	0	0
3/8”	0	0 – 1
#4	0 – 10	6 – 14
#8	10 – 35	35 – 55
#16	30 – 55	54 – 75
#30	50 – 70	65 – 85
#50	70 – 82	75 – 90
#100	79 – 90	82 – 93
#200	85 – 95	85 – 95

**Table 2
Aggregate Quality Requirements**

Property	TxDOT Standard Laboratory Test Method	Requirement
Magnesium sulfate soundness, %, max. ¹	Tex-411-A	30
Sand equivalent value, %, min.	Tex-203-F	70
Los Angeles abrasion, %, max	Tex-410-A	30

1. Use design gradation for the soundness test.

C. Mineral Filler. Provide mineral filler that is free of lumps and foreign matter consisting of non-air-entrained cement meeting the requirements of DMS-4600, “Hydraulic Cement,” or hydrated lime meeting the requirements of DMS-6350, “Lime and Lime Slurry.” The type and amount of mineral filler needed shall be determined by a laboratory mix design and will be considered as part of the aggregate gradation. An increase or decrease of less than one percent (1%) may be permitted when the micro-surfacing is being placed if it is found to be necessary for better consistency or set times.

D. Water. Provide water that is potable and free of harmful soluble salts.

- E. Other Additives.** Use approved additives as recommended by the emulsion manufacturer in the emulsion mix or in any of the component materials when necessary to adjust mix time in the field.
- F. Job-Mix Formula (JMF).** Provide a mix design conforming to the proportions shown in Table 3 and meeting the requirements shown in Table 4. The mix design is subject to verification using laboratory produced mixes or trial batch mix before approval.

Provide emulsion and aggregate that are compatible so that the mixing process will completely and uniformly coat the aggregate. Design the mix so that the mixture will have sufficient working life to allow for proper placement at the predicted ambient temperature and humidity.

Table 3
JMF Proportions

Material	Proportion
Residual Asphalt	6.0 to 9.0% by wt. of dry aggregate
Mineral Filler (Hydraulic Cement or Hydrated Lime)	0.5 to 3.0% by wt. of dry aggregate
Field Control Additive	As required to provide control of break and cure
Water	As required to provide proper consistency

Table 4
JMF Requirements

Property	TxDOT Standard Laboratory Test Method	Requirement
Wet track abrasion, g/sq. ft., max. wear value	Tex-240-F, Part IV	75
Gradation (aggregate and mineral filler)	Tex-200-F, Part II (Washed)	Table 1
Mix time, controlled to 120 sec.	Tex-240-F, Part I	Pass

- G. Rate of Application.** The micro-surfacing mixture shall be of the proper consistency at all times, so as to provide the application rate required by the surface condition. Suggested application rates are based upon the weight of dry aggregate in the mixture. Application rates are affected by the unit weight of the aggregate.

Micro-surfacing is often put down in two full-width passes in place of rut-filling when the rutting or deformation is not severe. When two passes are used, the first pass (scratch course) is made using a metal or stiff rubber strike-off and applying only what the surface demands for leveling. The second course is typically applied at 15 - 30 lb/yd².

Unless a specific aggregate type and application rate are shown in the plans, the following recommended aggregate types and average single application rates are suggested for the various street classifications and situations:

Aggregate Type	Suggested Placement Locations	Suggested Application Rate
Type I	Local Type A and B Streets	10 - 20 lb/yd ² (5.4 - 10.8 kg/m ²)
Type II	Collectors and Arterials Wheel Ruts	15 - 30 lb/yd ² (8.1 - 16.3 kg/m ²) See Section 239.4.K., "Ruts"

239.3. EQUIPMENT: Maintain equipment in good repair and operating condition.

- A.** Furnish a self-propelled micro-surfacing mixing machine with:
- self-loading devices to promote continuous laying operations;
 - sufficient storage capacity for mixture materials;
 - individual volume or weight controls that will proportion each material to be added to the

- mix;
- continuous flow mixing with a revolving multi-blade mixer capable of discharging the mixture on a continuous flow basis;
- opposite side driving stations;
- full hydrostatic control of the forward and reverse speed during operation;
- a water pressure system and nozzle-type spray bar immediately ahead of the spreader box and capable of spraying the roadway for the width of the spreader box;
- a mechanical-type spreader box equipped with paddles or other devices capable of agitating and spreading the materials throughout the box;
- a spreader box with devices capable of providing lateral movement or side shift abilities;
- a spreader box with a front seal, adjustable rear strike-off, and an adjustable secondary rear strike-off.

Calibrate and properly mark each control device that proportions the individual materials. Equip the aggregate feed with a revolution counter or similar device capable of determining the quantity of aggregate used at all times. Provide a positive-displacement-type emulsion pump with a revolution counter or similar device capable of determining the quantity of emulsion used at all times. Provide an approved mineral filler feeding system capable of uniformly and accurately metering the required material.

- B. Scales.** Scales used for weighing aggregates and emulsion must meet all requirements of TxDOT Item 520, "Weighing and Measuring Equipment." The weighing equipment for aggregates may be either a suspended hopper or a belt scale.
- C. Asphalt Storage and Handling Equipment.** When storage tanks are used, furnish a thermometer in each tank to indicate the asphalt temperature continuously. Keep equipment clean and free of leaks. Keep asphalt materials free from contamination.

239.4. CONSTRUCTION:

- A. General.** Produce, transport, and place micro-surfacing as specified in this Item or on the plans. Ensure that the finished surface has a uniform texture and the micro-surface mat is fully adhered to the underlying pavement.
- B. Temporary Material Storage.**
 - 1. Aggregate Storage.** Stockpile materials in a manner that will prevent segregation or contamination. Remix stockpiles with suitable equipment when necessary to eliminate segregation. Use a scalping screen while transferring aggregates to the mixing machine to remove oversize material.
 - 2. Mineral Filler Storage.** Store the mineral filler in a manner that will keep it dry and free from contamination.
 - 3. Asphalt Material Storage.** Keep asphalt materials free from contamination.
- C. Weather Limitations.** Place the material when the atmospheric temperature is at least 50°F and rising and the surface temperature is at least 50°F. Cease placement when the atmospheric temperature is below 60°F and falling, when weather is foggy or rainy, or when rain is imminent as determined by the Engineer. Cease placement 24 hr. before forecasted

temperatures below 32°F.

- D. Surface Preparation.** Thoroughly clean the surface of all vegetation, loose aggregate, and soil. Remove existing raised pavement markers. When existing surface conditions require, provide a water spray immediately ahead of the spreader box. Apply water at a rate that will dampen the entire surface without any free-flowing water ahead of the spreader box. If water is used, cracks shall be allowed to dry thoroughly before applying micro-surfacing.

Manholes, valve boxes, drop inlets and other service entrances shall be protected from the micro-surfacing by a suitable method. The Contractor shall cover all raised pavement markers in a manner to protect and insure the integrity of the markers prior to placing the micro-surfacing and shall remove such covers after the completion of micro-surfacing so that the markers will remain fully functional. Any markers damaged by the Contractor's operations shall be repaired or replaced at no cost to the City.

The Engineer shall approve the surface preparation prior to surfacing. No dry aggregate either spilled from the lay-down machine or existing on the road, will be permitted.

If shown on the plans, pre-treat the cracks in the surface with an acceptable crack sealer prior to the application of the micro-surfacing.

- E. Material Transfer.** Minimize construction joints by providing continuous loading of material while placing micro-surfacing. Ensure that oversized material has been removed prior to transferring the aggregates to the mixing machine.

- F. Placing.** Spread the mixture uniformly to the lines and grades shown on the plans or as directed by means of a mechanical type spreader box. Shift the spreader box when necessary to maintain proper alignment. Clean the spreader box as necessary to minimize clumps. Set and maintain the spreader box skids to prevent chatter in the finished mat. Prevent loss of material from the spreader box by maintaining contact between the front seal and the road surface. Adjust the rear seal to provide the desired spread. Adjust the secondary strike-off to provide the desired surface texture.

- G. Curing.** Protect the finished mat from traffic until the mix cures and will not be damaged by traffic. Adjust mixture properties according to humidity conditions and ambient air temperatures to allow uniformly moving traffic on completed travel lanes within 1 hr. after placement with no damage to the surface. Protect other locations subject to sharp turning or stopping and starting traffic for longer periods when necessary.

- H. Production Testing.** Provide access to the mixing unit discharge stream for sampling purposes. Produce a micro-surfacing mixture that will meet the tolerances specified in Table

5. Remove and replace or use other approved means to address material that does not meet these requirements, at no additional cost.

**Table
5
Production
Tests**

Property	TxDOT Standard Laboratory Test Method	Requirement
Asphalt content, % by wt.	Tex-236-F1 or asphalt meter readings	Design target $\pm 0.5\%$ and within limits of Table 1
Gradation, % retained	Tex-200-F, Part II (washed) ¹	#8 sieve and larger: ± 5 from design gradation. #16 sieve and smaller: ± 3 from design gradation. ²

1. Dried to constant wt. at 230°F $\pm 10^\circ$ F.

2. Material passing #200 sieve including the mineral filler must conform to the limitations of the master gradation shown in Table 1.

I. Workmanship. Remove and replace micro-surfacing material exhibiting evidence of poor workmanship at no additional cost.

1. Finished Surface. Provide a finished surface that has a uniform texture free from excessive scratch marks, tears, or other surface irregularities. Marks, tears, or irregularities are considered excessive if:

- more than 1 is at least ¼ in. wide and at least 10 ft. long in any 100 ft. of machine pull,
- more than 3 are at least ½ in. wide and more than 6 in. long in any 100 ft. of machine pull, or
- any are 1 in. wide or wider and more than 4 in. in length.

2. Construction Joints. Place longitudinal joints on lane lines unless otherwise directed.

Provide longitudinal and transverse joints that are uniform and neat in appearance. Provide construction joints that have limited buildup and that have no gaps between applications. Joints with buildup will be considered acceptable if:

- no more than ½ in. vertical space exists between the pavement surface and a 4-ft. straightedge placed perpendicular to the longitudinal joint and
- no more than ¼ in. vertical space exists between the pavement surface and a 4-ft. straightedge placed perpendicular to the transverse joint.

3. Edges. Provide an edge along the roadway centerline, lane lines, shoulder, edge of pavement, or curb line that is uniform and neat in appearance. The edge is considered acceptable when:

- it varies no more than ±3 in. from a 100-ft. straight line on a tangent section &
- it varies no more than ±3 in. from a 100-ft. arc on a curved section.

J. Miscellaneous Areas. Use a single-batch-type lay-down machine or other approved method to place materials on ramps or other short sections. Lightly dampen the surface before placing the mix. Provide 100% coverage that is uniform in appearance and comparable to that produced by the spreader box.

K. Ruts. When shown on the plans, fill ruts, utility cuts, and depressions in the existing surface in a separate pass from the final surface. Fill ruts as follows:

- Fill irregular or shallow ruts less than ½ in. deep with a full-width scratch coat pass. Use a rigid primary strike-off plate unless otherwise approved.
- Fill ruts ½ in. deep or deeper independently using a rut-filling spreader box that is at least 5 ft. wide. Crown the spreader box to compensate for traffic compaction.
- Fill ruts deeper than 1-½ in. in multiple placements unless otherwise approved.

ITEM 240

WARM MIX ASPHALTIC CONCRETE

240.1. DESCRIPTION: *Construct a pavement layer composed of a compacted, dense-graded mixture of aggregate and asphalt binder mixed in a mixing plant.*

240.2. MATERIALS: Furnish all material(s) meeting the following requirement, unless otherwise shown on the plans or unless otherwise authorized by the Engineer.

A. Tack Coat. Unless otherwise shown on the plans or approved, furnish CSS-1H, SS-1H, or a PG binder with a minimum high-temperature grade of PG 58 for tack coat binder and in accordance with Item 203, "Tack Coat." Do not dilute emulsified asphalts at the terminal, in the field, or at any other location before use.

B. Asphalt Binder. Provide the type and grade of performance-graded asphalt binder shown on the plans in accordance with TxDOT Item 300.2.J. "Performance-Graded Binders" prescribed for Hot-Mixed, Hot-Laid Asphalt Mixtures. Provide asphalt binders that are compatible with the materials defined in 240.2. C. "Synthetic, Foaming, Chemical or Other Additives."

C. Synthetic, Foaming, Chemical or Other Additives. Provide an additive that reduces the viscosity of the asphalt binder, allows the binder to fully coat the aggregates, and provides good workability during laying and compaction at temperatures lower than typical hot-mixed asphaltic concrete. Mix or disperse the additive to the asphaltic binder or asphaltic mixture in accordance with the manufacturer's recommendations.

D. Warm Mix Asphalt (WMA). Furnish the types of asphalt concrete materials meeting Item 205, "Hot-Mix Asphaltic Concrete Pavement." The item, type, and grade of aggregate, binder, and state aggregate classification (SAC) and other material requirements will be as shown on the plans when applicable. Unless allowed by the Engineer, different warm mix asphalt technologies (i.e. additives and equipment) may not be used on the same project.

E. EQUIPMENT: Furnish equipment to produce, haul, place, compact, and test the warm mix asphalt concrete in accordance with Item 205.3. "Equipment."

Modify production and placement equipment in the manner required for proper production and placement of the WMA and in conformance with the manufacturer's recommendations.

Maintain all equipment for the handling, mixing, and placing of all materials in good repair and operating condition, as approved. Replace any equipment found defective and affecting the quality of the paving mixture or the compacted pavement.

240.3. CONSTRUCTION: Design, produce, store, transport, place, and compact the warm mix asphalt concrete paving mixture in accordance with the following:

A. General. Transport, place, and compact the specified paving mixture, in accordance with Item 205.4. "Construction" and as approved. Place mixture, when placed with a spreading and finishing machine, or the tack coat when the roadway surface temperature is 60°F or higher unless otherwise approved. Measure the roadway surface temperature with a handheld infrared thermometer. Unless otherwise shown on the plans, place mixtures only when weather conditions and moisture conditions of the roadway surface are suitable in the opinion of the Engineer.

It is further provided that the tack coat or asphaltic mixture shall be placed only when the humidity, general weather conditions, temperature and moisture condition of the base are suitable.

- B. Mixture Design and Job Mix Formula.** For the WMA paving mixture, the Engineer may accept an HMA mixture design from the Contractor which was derived using materials conforming to the requirements of Item 205. Mixture design shall be conducted in accordance with Tex-204-F, Section 6 – Part IV, “Mix Design for Performance-Designed Mixtures Using the Superpave Gyratory Compactor (SGC).” The number of gyrations (N_{ini} , N_{des} , and N_{max}) and the mixing/compaction temperatures shall be shown on the plans. The laboratory mixture density at N_{des} shall conform to the values shown in Table 5 of Item 205. Evaluate the moisture susceptibility of the WMA paving mixture conforming to the HMA JMF in accordance with TxDOT standard laboratory test procedure Tex-530-C.
- C. Tack Coat.** The surface upon which the tack coat is to be placed shall be cleaned thoroughly to the satisfaction of the Inspector. The surface shall be given a uniform application of tack coat using asphaltic materials of this specification. Unless otherwise shown on the plans, tack coat shall be applied with an approved sprayer at a rate directed by the Engineer between 0.04 and 0.10 gallon residual asphalt per square yard of surface. The Engineer may use TxDOT standard laboratory test procedure Tex-243-F to verify that the tack coat has adequate adhesive properties. The Engineer may suspend paving operations until there is adequate adhesion. Where the mixture will adhere to the surface on which it is to be placed without the use of a tack coat, the tack coat may be eliminated by the Inspector. All contact surfaces of curbs and structures, as well as all joints, shall have a thin, uniform application of tack coat. During the application of tack coat, care shall be taken to prevent splattering of adjacent pavement, curb and gutter, and other structures.
- D. Placement.** Place the asphalt concrete mixture in accordance with this specification, the plans, and with Item 205, “Hot Mix Asphaltic Concrete Pavement” or as directed. Limits, areas, and/or locations of the warm mix asphalt pavement must be shown on the plans. Air void control must also be shown on the plans. Furnish the type, size, and number of steel and pneumatic rollers to compact the warm mix asphalt paving mixture as required.
- 1. Lift Thicknesses.** Do not exceed compacted lift thicknesses specified in Table 8 in Item 205.4.G, when placing this asphalt concrete mixture unless authorized by the Engineer.
 - 2. WMA Placement Temperature.** Unless otherwise shown on the plans, the temperature of the warm mix asphalt delivered to the paver shall be in conformance with the manufacturer’s recommendations (Manufacturer is defined as the entity that provides the additive defined in 204.2.C. “Synthetic, Foaming, Chemical or Other Additive”).

ITEM 250
3" X 5" HARD STONE (BULL ROCK)

250.1. DESCRIPTION: *A lime stone or river rock material that has a gradation ranging from 3' to 5" and does not have any fine materials. The material is typically used for landscaping, flood control, rip rap, and may be compacted as an element of dense-graded mixture of aggregate and asphalt binder mixed in a mixing plant.*

250.2. MATERIALS: Furnish all material(s) meeting the following requirement, unless otherwise shown on the plans or unless otherwise authorized by the Engineer.

Bull rock must be capable of withstanding freezing and thawing and the flow or wave action of the water where it is used as rip rap and for erosion control. The soil texture on the site and whether seepage is occurring are factors in determining the need and thickness of filters beneath the riprap.

250.3. USES. Bull Rock is commonly used as a permanent cover of rock to stabilize streambanks, provide in-stream channel stability, armoring, energy dissipation and to stabilize outlet below concentrated flows. Bull rock is used for erosion, sediment and pollution control to add water quality BMP's, as riprap to stabilize streambanks, line channels and provide stable outlets. The use of riprap in channels and below concentrated flows protects stream banks and discharge channels from higher erosive flow velocities. This reduces downcutting and lateral cutting, which in turn decreases sediment input to a watercourse.

Bull rock is commonly used to stabilize embankments and as an element of a densely compacted density-graded mixture of aggregate and asphalt binder mixed in a batching plant.

250.4. Specifications

A. General Considerations:

Bull rock structures should be designed by licensed professional engineers or other persons qualified in the design of such structures.

B. Stone Type

The material used for riprap should be fieldstone or rough unhewn quarry stone. Stone should be hard, angular, and of such quality that it will not disintegrate on exposure to water or weathering. It should also be chemically stable, capable of withstanding freezing and thawing, and suitable in all other respects for the intended use.

Structural design is usually based on the diameter of stone in the mixture for which a percentage, by weight, will be smaller. For example, D50 indicates a mixture of stones in which 50 percent of the stone by size would be larger than the diameter specified, and 50% would be smaller than the stone size specified. In other words, the design is based on the average size of stone in the mixture.

C. SPECIFICATIONS

<u>SIEVE SIZE</u>	<u>% RETAINED</u>
5"	0
4"	0-20
3"	30-60
2"	80-100
1"	90-100
½"	95-100

APPENDIX A

“Evaluation of Geogrids for Stabilizing Weak Pavement Subgrade”
International Journal of Pavement Engineering Vol. 9, No. 6, December 2008, 413–429

APPENDIX B

“GRI Standard Practice GG4(b) – Standard Practice for Determination of the Long-Term Design Strength of Flexible Geogrids”; Geosynthetic Research Institute; December 21, 2012 Revision.