Kaufman County Road Bond Project Specifications

ADS SPECIFICATIONS

ADS HP Storm Pipe
ADS Post Installation Testing of HP Storm
ADS Minimum and Maximum Cover Depths for HP Storm

NCTCOG SPECIFICATIONS

ITEM	DESCRIPTION
201	Site Protection
202	Temporary Erosion, Sedimentation, and Water Pollution Prevention and Control
203	Site Preparation
301	Subgrade, Subbase, and Base Preparation
302	Asphalt Pavement
303	Portland Cement Concrete Pavement
305	Miscellaneous Roadway Construction
401	Crack Sealing
402	Pavement Cut, Excavation, and Repair
404	Surface Treatments
501	Underground Conduit Materials
504	Open Cut – Backfill
508	Open Cut – Stormwater Conduit Installation
509	Crossings
701	General Structures
702	Concrete Structures
801	Barriers, Warning and Detour Signs, and Fences
803	Slope and Channel Protection
804	Painting and Other Protective Treatments; Pavement Marking

TXDOT SPECIFICATIONS

ITEM	DESCRIPTION
100	Preparing Right of Way
104	Removing Concrete
105	Removing Treated and Untreated Base and Asphalt Pavement
110	Excavation
132	Embankment
134	Backfilling Pavement Edges
150	Blading
152	Road Grader Work
156	Bulldozer Work
158	Specialized Excavation Work
164	Seeding for Erosion Control
193	Landscape Establishment
210	Rolling
216	Proof Rolling

247	Flexible Base
251	Reworking Base Courses
260	Lime Treatment (Road-Mixed)
275	Cement Treatment (Road-Mixed)
300	Asphalts, Oils, and Emulsions
301	Asphalt Antistripping Agents
302	Aggregate for Surface Treatments
305	Salvaging, Hauling, and Stockpiling Reclaimable Asphalt Pavement
310	Prime Coat
314	Emulsified Asphalt Treatment
316	Seal Coat
320	Equipment for Asphalt Concrete Pavement
330	Limestone Rock Asphalt Pavement
334	Hot-Mix Cold-Laid Asphalt Concrete Pavement
340	Dense-Graded Hot-Mix Asphalt (Small Quantity)
341	Dense-Graded Hot-Mix Asphalt
354	Planing and Texturing Pavement
360	Concrete Pavement
361	Repair of Concrete Pavement
427	Surface Finishes for Concrete
440	Reinforcement for Concrete
460	Corrugated Metal Pipe
462	Concrete Box Culverts and Drains
466	Headwalls and Wingwalls
472	Removing and Re-Laying Culvert
480	Cleaning Existing Culverts
500	Mobilization
502	Barricades, Signs, and Traffic Handling
506	Temporary Erosion, Sedimentation, and Environmental Controls
510	One-Way Traffic Control
540	Metal Beam Guard Fence
544	Guardrail End Treatments
560	Mailbox Assemblies
585	Ride Quality for Pavement Surfaces
662	Work Zone Pavement Markings
666	Retroreflectorized Pavement Markings
677	Eliminating Existing Pavement Markings and Markers
678	Pavement Surface Preparation for Markings
700	Pothole Repair
712	Cleaning and Sealing Joints and Cracks (Asphalt Concrete)
713	Cleaning and Sealing Joints and Cracks (Concrete Pavement)
730	Roadside Mowing
734	Litter Removal
735	Debris Removal
752	Tree and Brush Removal
760	Cleaning and Reshaping Ditches
780	Concrete Crack Repair

ADS HP STORM 12”- 60” PIPE SPECIFICATION

Scope

This specification describes 12- through 60-inch (300 to 1500 mm) ADS HP Storm pipe for use in gravity-flow storm drainage applications.

Pipe Requirements

ADS HP Storm pipe shall have a smooth interior and annular exterior corrugations.

- 12- through 60-inch (300 to 1500 mm) pipe shall meet ASTM F2881 or AASHTO M330
- Manning’s “n” value for use in design shall be 0.012

Joint Performance

Pipe shall be joined using a bell & spigot joint meeting the requirements of ASTM F2881 or AASHTO M330. The joint shall be watertight according to the requirements of ASTM D3212. Gaskets shall meet the requirements of ASTM F477. Gasket shall be installed by the pipe manufacturer and covered with a removable, protective wrap to ensure the gasket is free from debris. A joint lubricant available from the manufacturer shall be used on the gasket and bell during assembly. 12- through 60-inch (300 to 1500 mm) diameters shall have an exterior bell wrap installed by the manufacturer.

Fittings

Fittings shall conform to ASTM F2881 or AASHTO M330. Bell and spigot connections shall utilize a welded or integral bell and valley or inline gaskets meeting the watertight joint performance requirements of ASTM D3212.

Field Pipe and Joint Performance

To assure watertightness, field performance verification may be accomplished by testing in accordance with ASTM F1417 or ASTM F2487. Appropriate safety precautions must be used when field-testing any pipe material. Contact the manufacturer for recommended leakage rates.

Material Properties

Polypropylene compound for pipe and fitting production shall be impact modified copolymer meeting the material requirements of ASTM F2881, Section 5 and AASHTO M330, Section 6.1.

Installation

Installation shall be in accordance with ASTM D2321 and ADS recommended installation guidelines, with the exception that minimum cover in traffic areas for 12- through 48-inch (300 to 1200 mm) diameters shall be one foot (0.3 m) and for 60-inch (1500 mm) diameter the minimum cover shall be 2 ft. (0.6 m) in single run applications. Backfill for minimum cover situations shall consist of Class 1 (compacted), Class 2 (minimum 90% SPD), or Class 3 (minimum 95%) material. Maximum fill heights depend on embedment material and compaction level; please refer to Technical Note 2.04. Contact your local ADS representative or visit our website at www.ads-pipe.com for a copy of the latest installation guidelines.

Pipe Dimensions

Nominal Pipe I.D. in (mm)	12 (300)	15 (375)	18 (450)	24 (600)	30 (750)	36 (900)	42 (1050)	48 (1200)	60 (1500)
Average Pipe I.D. in (mm)	12.2 (310)	15.1 (384)	18.2 (462)	24.1 (612)	30.2 (767)	36.0 (914)	42.0 (1067)	47.9 (1217)	59.9 (1521)
Average Pipe O.D. in (mm)	14.5 (368)	17.7 (450)	21.4 (544)	28.0 (711)	35.5 (902)	41.5 (1054)	47.4 (1204)	54.1 (1374)	67.1 (1704)
Minimum Pipe Stiffness * @ 5% Deflection #/in./in. (kN/m^2)	75 (517)	60 (414)	56 (386)	50 (345)	46 (317)	40 (276)	35 (241)	35 (241)	30 (207)

*Minimum pipe stiffness values listed; contact a representative for average values.

TECHNICAL NOTE

Post Installation Testing of HP Storm

TN 5.20
August 2016

Introduction

Storm sewer is often tested after or during installation to ensure a sound installation was accomplished. Types of post installation field testing include deflection testing and joint testing. Specific testing required for the project will be found in the project specifications. This technical note is not meant to supersede any project specification, but should be used in conjunction with the project specification and national testing standards as it relates specifically to HP Storm pipe.

Deflection Testing

An important feature of any flexible pipe is its ability to deflect, or oval, under load without structural distress. Deflection allows the load to be transferred from the pipe to the surrounding backfill. The result is flexible pipe can withstand very high loads as a relatively light structure. Flexible pipe – including HP Storm – *must* deflect in order to mobilize the strength of the surrounding backfill.

According to current thermoplastic design procedures, deflection is defined as a service limit. The designer, considering all site conditions, will set this service limit in order to perform a proper design evaluation. Deflection in excess of this service limit does not necessarily result in strength limits being exceeded, i.e. system failure. For more information on service and strength limit states, see the *Structures* section of the Drainage Handbook. HP Storm can be expected to perform satisfactorily in most applications with 5% or 7.5% deflection and so it is typical of designers to choose a service limit in this range.

When testing for allowable deflection limits, the minimum inside diameter should be used when establishing mandrel sizing. The minimum inside diameter accounts for the allowable manufacturing tolerances. Table 1 lists the inside diameters that result from 5% and 7.5% deflection from the minimum inside diameter. Values listed in Table 1 should be used for sizing mandrels for deflection testing. Mandrels may be obtained from a variety of commercial suppliers.

Table 1
HP Storm Recommended Mandrel Settings

Pipe Type	Pipe Diameter	Minimum Inside Diameter*	Inside Diameter with 5% Deflection	Inside Diameter with 7.5% Deflection
Dual Wall	12	11.88	11.29	10.99
	15	14.78	14.11	13.74
	18	17.82	16.93	16.48
	24	23.76	22.57	21.98
	30	29.70	28.22	27.47
	36	35.64	33.86	32.97
	42	41.58	39.50	38.46
	48	47.52	45.14	43.96
	60	59.40	56.43	54.95

* Value is the larger of ASTM F2881 and AASHTO M330. If designing to a specific standard, please review allowable minimum diameter

It is important to understand that mandrel testing is a go/no-go test. If any line were to not pass a mandrel, it is important to ascertain the cause. Obstructions in the line, not associated with deflection, may influence the test. Visual inspection is recommended in the event of a no-go result.

Joint Testing

Joint testing is an important part of any gravity sewer system, both in testing for infiltration and exfiltration. Infiltration aids to estimate the amount of sewer water that will be conveyed to, and ultimately treated by, the waste water treatment plant. Exfiltration aids to estimate the loss of sewage water into the surrounding soil. The two primary ways of testing sewer pipe joints for infiltration and/or exfiltration is using air or water to create a constant pressure within the system.

Exfiltration Testing with Air

Air is a compressible gas and so it is extremely important one adheres to the appropriate safety regulations outlined in OSHA and project specifications. There are two primary national testing standards that may be applied to joint testing HP Storm: ASTM F1417 *Standard Test Method for Installation Acceptance of Plastic Gravity Sewer Lines Using Low-Pressure Air*, and ASTM F3058 *Preliminary Field Testing of Thermoplastic Pipe Joints for Gravity Flow (Non-Pressure) Sewer Lines*. When either standard is specified by the project plans, one should review the standards carefully and follow the testing procedure and safety precautions outlined. The below commentary on the ASTM testing procedures should be considered a summary and does not replace the testing procedures outlined in their respective specifications.

ASTM F1417 entails testing a run of pipe from one manhole to the next adjacent manhole. Inflatable plugs are positioned into the manholes and secured. Air is introduced into the pipe line and gradually builds pressure. Once the line has been pressurized and is stable at 4.0-psi, the pressure is decreased to 3.5-psi at which time the line must not lose more than 0.5- or 1.0-psi (whichever is specified by the design engineer) in the specified amount of time. Table 2 below summarizes the minimum time that must be reached for less than 0.5- or 1.0-psi of pressure drop, depending on the diameter and length of pipe being tested.

Table 2
Time to Pressure Drop for HP Storm (per ASTM F1417)

Pipe Diameter	Pressure Drop (psi)	Minimum Test Time (min:sec)	Length for Minimum Time, (ft)	Time for Longer Lengths, (sec)	Time for Length Shown, (min:sec)							
					100 ft	150 ft	200 ft	250 ft	300 ft	350 ft	400 ft	450 ft
12	0.5	5:40	199	1.709 L	5:40	5:40	5:42	7:08	8:33	9:58	11:24	12:50
	1.0	11:20		3.418 L	11:20	11:20	11:24	14:15	17:05	19:56	22:47	25:38
15	0.5	7:05	159	2.671 L	7:05	7:05	8:54	11:08	13:21	15:35	17:48	20:02
	1.0	14:10		5.342 L	14:10	14:10	17:48	22:15	26:42	31:09	35:36	40:04
18	0.5	8:30	133	3.846 L	8:30	9:37	12:49	16:01	19:14	22:26	25:38	28:51
	1.0	17:00		7.692 L	17:00	19:13	25:38	32:03	38:27	44:52	51:16	57:41
24	0.5	11:20	99	6.837 L	11:24	17:57	22:48	28:30	34:11	39:53	45:35	51:17
	1.0	22:40		13.764 L	22:47	34:11	43:34	56:58	68:22	79:46	91:10	102:33
30	0.5	14:10	80	10.683 L	17:48	26:43	35:37	44:31	53:25	62:19	71:13	80:07
	1.0	28:20		21.366 L	35:37	53:25	71:13	89:02	106:50	124:38	142:26	160:15

Data taken from ASTM F 1417[1] and Uni-Bell, Uni-B-6-98[3].
It may not be necessary to hold the test for the entire time period listed above when it is evident that the rate of air loss is zero or less than the allowable pressure drop and authorized by the approving authority[1].

When the pipe is large enough to be physically accessed, it may be desirable to test individual joints for safety reasons. In these cases, one may consider joint testing in accordance with ASTM F3058, also known as a joint isolation test. ADS recommends a joint isolation test, in lieu of a full line test, for testing pipe diameters 36” and larger for safety reasons. This test is typically done with air, though water may also be used, and involves the use of special testing equipment. The equipment consists of two inflatable bladders, placed on each side of the joint, creating an open center cavity between them. The bladders are inflated and then the center cavity is pressurized to 3.5 psi. The joint passes the test if the pressure is held for 5 seconds without dropping more than 1.0-psi. For all practical purposes, this is a go/no-go test. Final acceptance of the pipeline per this testing method shall be at the discretion of the Design Engineer. One

advantage of this type of test is the ability for the installer to quickly test the joint immediately after installation, allowing for any corrective measures to be taken early on in the project.

Infiltration/Exfiltration with Water

Testing gravity sewer joints via water infiltration or exfiltration is a common practice. For HP Storm, this testing should be conducted in accordance with ASTM F2487 *Standard Practice for Infiltration and Exfiltration Acceptance Testing of Installed Corrugated High Density Polyethylene Pipelines*. These standards entail first observing the ground water conditions and, if applicable, measuring the infiltration rate of the ground water through the joints. If ground water is not applicable, then the line is filled with water and the leakage is observed through exfiltration.

Manholes shall be tested separately and independently of the pipe line to the requirements established in the project specifications. When water level is measured in the manhole for the exfiltration test, the leakage associated with the manhole shall be subtracted from the overall leakage of the test section to establish a pass or fail grade for the pipe.

Allowable Leakage

The allowable leakage rate for HP Storm is 100 gallons/in-dia/mi-pipe/day for both infiltration and exfiltration when done in accordance with ASTM F2487.

Conclusion

ADS HP Storm is intended for gravity flow storm sewer applications and may be tested for deflection and joint tightness as discussed in this technical document. It is important to note that the testing procedures are no different than for other storm sewer products currently being used in the market. This document does not purport to address the safety concerns associated with testing HP Storm. Any questions associated with testing HP Storm can be directed to your local representative.

References

1. ASTM F1417, *Standard Test Method for Installation Acceptance of Plastic Gravity Sewer Lines Using Low-Pressure Air*, ASTM, 2005
2. *F3058, Preliminary Field Testing of Thermoplastic Pipe Joints for Gravity Flow (non-Pressure) Sewer Lines*, ASTM, 2016.
3. Uni-B-6-98, *Recommended Practice for Low-Pressure Air Testing of Installed Sewer Pipe,* Uni-Bell PVC Pipe Association, 1998
4. ASTM F2487, *Standard Practice for Infiltration and Exfiltration Acceptance Testing of Installed Corrugated High Density Polyethylene Pipelines,* ASTM, 2006
5. ASTM F2881, *Standard Specification for 12 to 60 in. (300 to 1500 mm) Polypropylene (PP) Dual Wall Pipe and Fittings for Non-Pressure Storm Sewer Applications*, ASTM, 2011

TECHNICAL NOTE

Minimum and Maximum Cover Heights for HP Storm Pipe for Storm Drainage

TN 2.04
March 2018

Introduction

The information in this document is designed to provide answers to general cover height questions; the data provided is not intended to be used for project design. The design procedure described in the *Structures* section (Section 2) of the Drainage Handbook provides detailed information for analyzing most common installation conditions. This procedure should be utilized for project specific designs.

The two common cover height concerns are minimum cover in areas exposed to vehicular traffic and maximum cover heights. Either may be considered "worst case" scenario from a loading perspective, depending on the project conditions.

Minimum Cover in Traffic Applications

Pipe diameters from 12- through 48-inch (300-1200 mm) installed in traffic areas (AASHTO H-20, H-25, or HL-93 loads) must have at least one foot (0.3m) of cover over the pipe crown, while 60-inch (1500 mm) pipes must have at least 24 inches (0.6m) of cover. The backfill envelope must be constructed in accordance with the *Installation* section (Section 5) of the Drainage Handbook and the requirements of ASTM D2321. The backfill envelope must be of the type and compaction listed in Appendix A-5, Table A-5-2 of the Drainage Handbook. In Table 1 below, this condition is represented by a Class III material compacted to 95% standard Proctor density or a Class II material compacted to 90% standard proctor density, although other material can provide similar strength at slightly lower levels of compaction. Structural backfill material should extend to the crown of the pipe; the remaining cover should be appropriate for the installation and as specified by the design engineer. If settlement or rutting is a concern, it may be appropriate to extend the structural backfill to grade. Where pavement is involved, sub-base material can be considered in the minimum burial depth. While rigid pavements can be included in the minimum cover, the thickness of flexible pavements should not be included in the minimum cover.

Additional information that may affect the cover requirements is included in the *Installation* section (Section 5) of the Drainage Handbook. Some examples of what may need to be considered are temporary heavy equipment, construction loading , paving equipment and similar loads that are less than the design load, the potential of pipe flotation, and the type of surface treatment which will be installed over the pipe zone.

Table 1
Minimum Cover Requirements for ADS HP Storm with AASHTO H-25, H-20, or HL-93 Load

Inside Diameter, ID, in.(mm)	Minimum Cover ft. (m)
12 (300)	1 (0.3)
15 (375)	1 (0.3)
18 (450)	1 (0.3)
24 (600)	1 (0.3)
30 (750)	1 (0.3)

Inside Diameter, ID, in.(mm)	Minimum Cover ft. (m)
36 (900)	1 (0.3)
42 (1050)	1 (0.3)
48 (1200)	1 (0.3)
60 (1500)	2 (0.6)

Notes:

1. *Minimum covers presented here were calculated assuming Class III backfill material compacted to 95% standard Proctor density or Class II backfill material compacted to 90% standard Proctor density around the pipe, as recommended in Section 5 of the Drainage Handbook, with an additional layer of compacted traffic lane sub-base for a total cover as required. In shallow traffic installations, especially where pavement is involved, a good quality compacted material to grade is required to prevent surface settlement and rutting.*
2. *The minimum covers specified do not include pavement thickness. A pavement section of 0.4' is typical.*
3. *Backfill materials and compaction levels not shown in the table may also be acceptable. Contact ADS for further detail.*
4. *Calculations assume no hydrostatic pressure and native soils that are as strong as the specified minimum backfill recommendations.*

Maximum Cover

Wall thrust generally governs the maximum cover a pipe can withstand and conservative maximum cover heights will result when using the information presented in the *Structures* section (Section 2) of the Drainage Handbook. Table 2 below shows the material properties consistent with the expected performance characteristics for HP Storm materials for a 100-year design life.

The maximum burial depth is highly influenced by the type of backfill and level of compaction around the pipe. General maximum cover limits for ADS HP Storm use in storm drainage applications are shown in Tables 3 for a variety of backfill conditions.

Table 3 was developed assuming pipe is installed in accordance with ASTM D2321 and the *Installation* section (Section 5) of the Drainage handbook. Additionally, the calculations assume no hydrostatic load around the pipe, incorporate the maximum conservative AASHTO LRFD design factors represented in *Structures* section of the Drainage Handbook, use material properties consistent with the expected performance characteristics for HP Storm materials, as shown in Table 2, and assume the native (in-situ) soil is of adequate strength and suitable for installation. For applications requiring fill heights greater than those shown in Table 3 or where hydrostatic pressure due to groundwater is expected, contact an ADS Engineer.

Table 2
ADS HP Storm Mechanical Properties

Resin	ASTM Specification	Allowable Long Term Strain %	Initial		75-Year	
			Fu (psi)	E (psi)	Fu (psi)	E (psi)
Polypropylene, Impact-modified copolymer	ASTM F2881	3.7	3,500	175,000	1,000	28,000

Figure 1
ADS HP Storm Pipe Trench Detail with Uniform Backfill
(Traffic and Non-Traffic Applications)

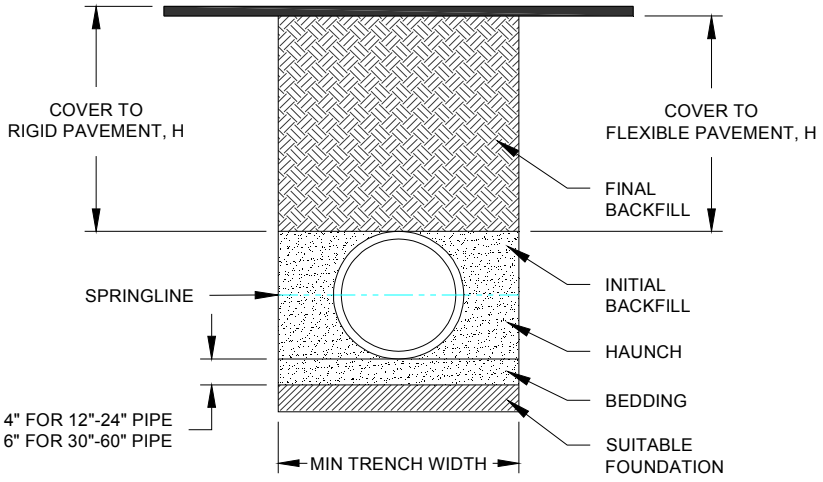

Table 3
Maximum Cover for ADS HP Storm Pipe with Uniform Backfill, ft (m)

Diameter	Class 1		Class 2			Class 3		Class 4
in (mm)	Compacted	Dumped	95%	90%	85% [3]	95%	90% [3]	95% [3]
12 (300)	41 (12.5)	21 (6.4)	28 (8.5)	21 (6.4)	16 (4.9)	20 (6.1)	16 (4.9)	16 (4.9)
15 (375)	42 (12.8)	21 (6.4)	29 (8.8)	21 (6.4)	16 (4.9)	21 (6.4)	16 (4.9)	16 (4.9)
18 (450)	44 (13.4)	21 (6.4)	30 (9.1)	21 (6.4)	16 (4.9)	22 (6.7)	17 (5.2)	16 (4.9)
24 (600)	37 (11.3)	18 (5.5)	26 (7.9)	18 (5.5)	14 (4.3)	19 (5.8)	14 (4.3)	14 (4.3)
30 (750)	39 (11.9)	19 (5.8)	27 (8.2)	19 (5.8)	14 (4.3)	19 (5.8)	15 (4.6)	14 (4.3)
36 (900)	28 (8.5)	14 (4.3)	20 (6.1)	14 (4.3)	10 (3.0)	14 (4.3)	11 (3.4)	10 (3.0)
42 (1050)	30 (9.1)	14 (4.3)	21 (6.4)	14 (4.3)	10 (3.0)	15 (4.6)	11 (3.4)	10 (3.0)
48 (1200)	29 (8.8)	14 (4.3)	20 (6.1)	14 (4.3)	9 (2.7)	14 (4.3)	10 (3.0)	10 (3.0)
60 (1500)	29 (8.8)	14 (4.3)	20 (6.1)	14 (4.3)	9 (2.7)	14 (4.3)	10 (3.0)	9 (2.7)

Notes:

1. *Results based on calculations shown in the Structures section of the ADS Drainage Handbook (v20.7). Calculations assume no hydrostatic pressure and a density of 120 pcf (1926 kg/m^3) for overburden material.*
2. *Installation assumed to be in accordance with ASTM D2321 and the Installation section of the Drainage Handbook.*
3. *For installations using lower quality backfill materials or lower compaction efforts, pipe deflection may exceed the 5% design limit; however controlled deflection may not be a structurally limiting factor for the pipe. For installation where deflection is critical, pipe placement techniques or periodic deflection measurements may be required to ensure satisfactory pipe installation.*
4. *Backfill materials and compaction levels not shown in the table may also be acceptable. Contact ADS for further detail.*
5. *Material must be adequately "knifed" into haunch and in between corrugations. Compaction and backfill material is assumed uniform throughout entire backfill zone.*
6. *Compaction levels shown are for standard Proctor density.*
7. *For projects where cover exceeds the maximum values listed above, contact ADS for specific design considerations.*
8. *See ADS Standard Detail STD-101D for additional details.*

ITEM 201. SITE PROTECTION

201.1. REMOVAL, PROTECTION, AND REPLACEMENT OF TREES, SHRUBBERY, PLANTS, SOD, AND OTHER VEGETATION

No trees shall be removed unless so noted on the plans or upon the specific approval of the OWNER. Where trees, plants, shrubbery, etc., are adjacent to the line of the work and are not to be removed or are designated on the plans to be removed and replanted, the CONTRACTOR shall protect such trees, plants, shrubbery, and etc.in accordance to the contract documents. If, in the opinion of the OWNER, such trees, plants, shrubbery, etc., would be damaged by machinery, etc., hand excavation may be required. Shrubbery, plants, etc. to be relocated or reused shall be removed with a ball of dirt about their roots and shall be carefully stored and given proper attention.

Sod shall be removed in squares cut out with a sharp spade and of such sizes that they may be handled conveniently without breaking. They shall be carefully stored and given proper attention. During hot, dry weather, the stored sod shall be protected by covering with canvas or burlap.

Tree roots shall be protected by installing temporary construction fencing outside the tree's drip line. Other tree protection may be required by OWNER. No operating, parking, or storing of equipment and/or materials is allowed within the tree protection zone. The CONTRACTOR shall be responsible for all damage to trees, plants, shrubbery, etc., and any such damage shall be remedied to the satisfaction of the OWNER at the expense of the CONTRACTOR. All damaged limbs over 1-inch in diameter shall be sawed clean adjacent to the damaged area or at the trunk and dressed with acceptable tree wound treatment material, unless dressing is waived by the OWNER.

The cost of removal shall be paid for as a separate contract pay item if a separate pay item is provided; otherwise, the costs thereof shall be included in such pay items as are provided in the proposal and contract. The cost of protection shall not be paid for as a separate contract pay item; the costs thereof shall be included in such pay items as are provided for in the proposal and contract.

Where sod, shrubbery, plants, etc., are designated for removal and replacement, such areas shall have sod, shrubbery, plants, etc., of the same kind and in good condition, placed in OWNER approved locations. Trees that are to be removed and subsequently replaced shall be designated on the plans. When backfilling is completed, the sod, shrubbery, plants, etc. shall be carefully placed in OWNER approved locations and the area thoroughly wet down.

The cost of such replacement shall be paid for as a separate contract pay item if a separate pay item is provided; otherwise, the costs thereof shall be included in such pay items as are provided in the proposal and contract.

201.2. DETERMINING LOCATION AND PROTECTION OF EXISTING STRUCTURES AND UTILITIES

Determining location and protection of existing structures and utilities shall comply with this Item 201.2. and with the provisions of Item 107.24. Existing Structures, Facilities and Appurtenances and Item 103.1. Contractor's Warranties and Understanding.

201.2.1. Determining Location. Determining the location of existing structures, utilities and appurtenances shall proceed according to the specifications herein and the provisions of Item 107.24. Existing Structures, Facilities and Appurtenances.

BIDDERS must satisfy themselves as to the actual existing subsurface conditions, including but not limited to the depth, location and sizes of pipe or conduits of various kinds in place. Where the exact depth of any utility or obstruction is not shown on a plan, excavation shall be made prior to reaching the obstruction in order to determine adjustments in grade if needed to prevent interference. Redesign to eliminate conflicts may be necessary. Extra compensation shall not be paid for such delays.

201.2.1.1. Subsurface Utility Engineering. If provided by CONTRACTOR, subsurface utility engineering shall be in conformance with CI/ASCE 38-02, Standard Guideline for the Collection and Depiction of Existing Subsurface Utility Data, or as currently revised.

201.2.2. Protection. All existing structures, improvement and utilities designated to remain shall be adequately protected, at the expense of the CONTRACTOR, from damage that might otherwise occur due to construction operations. Where construction comes in close proximity to existing structures, utilities or

appurtenances, or if it becomes necessary to move services, poles, guy wires, pipe lines or other obstructions, the CONTRACTOR shall notify and cooperate with the owner of the utility, structure, or appurtenance. The utility lines and other existing structures shown on the plans are for information only and are not guaranteed by the OWNER to be complete or accurate as to location and/or depth. The CONTRACTOR shall be liable for damage to any utilities resulting from the CONTRACTOR'S operations. During construction, all fire hydrants, valve boxes, water meters/vaults, manholes, emergency call boxes and/or other existing utility controls shall be left intact, unobstructed and accessible unless noted on the plan.

All water mains, wastewater collection mains, wastewater collection laterals, storm drains, power conduits, gas mains, gas service laterals, irrigation systems, and other lines or appurtenances encountered during construction shall be supported or replaced as detailed on the plans. Water service lines shall not be removed during excavation, and the CONTRACTOR shall provide adequate support for the services across the open ditch.

201.2.2.1. Temporary Utility Supports. CONTRACTOR shall provide temporary utility support to protect existing utility lines exposed during construction. Method and type of temporary utility supports, if required, shall be approved by the utility owner.

201.2.3. Relocating or Replacing Structures, Utilities or Appurtenances. Utility locations shall be obtained prior to the commencement of work according to Item 107.24. Existing Structures, Facilities and Appurtenances. Unless noted on plans that utilities are to be moved by others, any cost of temporarily or permanently relocating utilities shall be borne by the CONTRACTOR. The cost of these replacements shall be included in the CONTRACTOR'S bid price for the various items of work, and no separate payment shall be made. The OWNER shall approve all shut downs and may assist in the shut down operations.

If it is necessary to adjust another utility, a representative of that utility shall be notified to decide method and work to be done. The CONTRACTOR shall make satisfactory arrangements with the OWNER or other utilities for the required adjustments at the CONTRACTOR'S own expense, other than for items that may be provided in the contract for such work. No extra compensation shall be paid due to delays caused by removal of public utility structures.

201.2.3.1. Interrupted Utility Services. In case damage to an existing utility occurs, the CONTRACTOR shall notify the OWNER and utility owner immediately. The CONTRACTOR shall be responsible for the cost to restore the structure or utility to its original condition and position without extra compensation. Restoration of utility services shall be made as soon as practicable as directed and approved by the utility owner.

The CONTRACTOR shall notify the OWNER of any spill of wastewater. Remediation of the spill is the responsibility of the CONTRACTOR and shall be at no additional cost to the OWNER. Spill and remediation will be reported by the OWNER to the TCEQ, USEPA, or other appropriate regulatory agencies. The CONTRACTOR shall be responsible for notifying customers of temporary interruption of service.

201.2.3.2. Street Sign Posts and Signs. The CONTRACTOR shall be responsible for all damage to street sign posts and signs within the limits of the CONTRACTOR'S operations that remain in place or are removed and replaced. In the event that street sign posts and signs are damaged or destroyed by the CONTRACTOR'S operations, they shall be replaced at the CONTRACTOR'S expense.

201.2.3.3. Methods of Removal and Disposal. Materials or parts of structures which are to be broken up, dismantled or removed, and which are to be salvaged, shall be removed, loaded, cleaned and unloaded at sites designated by the OWNER. Materials that are not salvageable shall become the property of the CONTRACTOR. Disposal of such materials, in accordance with applicable local, state, and federal regulations, shall be at the CONTRACTOR'S expense.

201.2.4. Measurement and Payment. No measurement shall be made for the removal and replacement of utility pipe even if the utility pipe is replaced with a different pipe. No payment shall be made except as provided for under certain conditions in Item 107.24. Existing Structures, Facilities and Appurtenances and Item 201.2.4.1. Measurement and Payment for Utility Supports, unless otherwise provided in the Contract.

201.2.4.1. Measurement and Payment for Temporary Utility Supports. No separate measurement or payment shall be made for temporary utility supports unless a separate bid item is established in the Contract. If a separate bid item for temporary utility supports is established in the Contract, it shall include all necessary labor, tools, materials, equipment and incidentals necessary to complete the work, including removal and cleanup.

201.3. MAINTENANCE OF STREETS AND RIGHTS OF WAY DURING CONSTRUCTION

The CONTRACTOR shall at all times maintain vehicular and pedestrian traffic through and adjacent to work zones in accordance with Item 107. Legal Relations and Contractor Responsibilities. The maintenance required shall include but not be limited to the filling of potholes; blading or otherwise smoothing of the paved surfaces (particularly in a trench area); cleaning and removal of surplus excavation material, rubbish, etc.; and the maintenance of safe and efficient vehicular and pedestrian access. Dust control shall be in accordance with 203.6 Dust Control.

ITEM 202. TEMPORARY EROSION, SEDIMENTATION, AND WATER POLLUTION PREVENTION AND CONTROL

202.1. DESCRIPTION

This Item shall govern the use of temporary control measures necessary to prevent and control soil erosion, sedimentation, and water pollution that may degrade the MS4, adjacent properties, and/or receiving waters including rivers, streams, lakes, reservoirs, groundwater, and wetlands. The temporary control measures contained herein shall be installed and maintained throughout the construction contract and coordinated with any permanent or temporary pollution control features specified elsewhere on the plans and in the specifications to assure effective and continuous water pollution control throughout the construction and post construction periods. These control measures shall not be used as a substitute for the permanent pollution control measures unless otherwise directed by the OWNER in writing. The controls may include any of the devices listed in this item. Additional information regarding these and other controls can be found in NCTCOG's *integrated* Storm Water Management iSWM Program Manuals. In the event of conflict between these specifications and applicable Federal, State and Local laws, rules and regulations, the more restrictive requirement shall apply.

Measurement and payment for all measures called for within Item 202. shall be per Item 202.19 Measurement and Payment.

202.2. ITEMS OF WORK AND MATERIALS

The items, estimated quantities, and locations of the control measures will be shown on the plans; however, the OWNER may revise these items as needs arise. The materials will be shown on the plans and in the specifications. The OWNER may allow, in writing, the use of other materials and work methods as the need arises.

202.3. PRECONSTRUCTION SUBMITTALS

Prior to the start of construction, the CONTRACTOR shall submit to the OWNER a copy of the Storm Water Pollution Prevention Plan (SWPPP) and any documentation required by the Construction General Permit. Work on the project shall not begin until the submittals have been accepted by the OWNER. The CONTRACTOR shall provide the OWNER, for information purposes, proposed methods of storm water pollution control for CONTRACTOR operations in areas which are outside the limits of the erosion control plan or the SWPPP (such as construction and haul roads, field offices, equipment and supply storage areas, portable process plants, and source material storage), as well as a plan for disposal of waste materials.

202.4. CONSTRUCTION REQUIREMENTS

202.4.1. General. The CONTRACTOR shall provide control measures to prevent or minimize the impact of the CONTRACTOR'S operations to receiving waters as required by the plans or Storm Water Pollution Prevention Plan (SWPPP) and/or as directed by the OWNER in writing.

In any disturbed area where construction activities have ceased, permanently or temporarily, the CONTRACTOR shall initiate stabilization of the area by the use of seeding, mulching, soil retention blankets or other appropriate measures within 14-days, except in areas where construction activities are scheduled to resume within 21-days.The CONTRACTOR shall effectively prevent and control erosion and sedimentation on the site at the earliest practicable time as outlined in the approved schedule. Control measures, where applicable, will be implemented prior to the commencement of each construction operation. The CONTRACTOR shall limit the amount of disturbed earth to the area(s) shown on the plans or as directed by the OWNER. The OWNER has the authority to limit the disturbed surface area exposed by construction operations. If, in the opinion of the OWNER, the CONTRACTOR is not able to effectively control soil erosion and sedimentation resulting from construction operations, the OWNER will limit the amount of disturbed area to that which the CONTRACTOR is able to control.

Should the control measures fail to function effectively, the CONTRACTOR shall act immediately to bring the erosion and sedimentation under control by maintaining existing controls or by providing additional controls as directed by the OWNER. When, in the opinion of the OWNER, the site is adequately stabilized, the control measures, except mulches and soil retention blankets, will be removed and properly disposed of by the CONTRACTOR. Soil retention blankets shall be removed only when, in the opinion of the OWNER, final

permanent perennial seeding would be adversely affected by the presence of an existing soil retention blanket.

All erosion, sediment, and water pollution controls will be maintained in good working order. The CONTRACTOR and OWNER will inspect the entire project to determine the condition of the control measures using one of the following inspection schedules:

(1) A rain gauge provided by the CONTRACTOR will be located at the project site. Inspection will occur every fourteen (14) calendar days, and also within 24-hours of a rainfall event of 0.5-in. or more as measured by the project rain gauge.
(2) Inspection will occur at least once every seven (7) calendar days on a specifically defined day, regardless of whether or not there has been a rainfall event since the previous inspection.

Sediment will be removed and devices repaired as soon as practicable but no later than seven (7) calendar days after the surrounding exposed ground has dried sufficiently to prevent further damage from equipment operations needed for repairs.

In the event of continuous rainfall over a 24-hour period, or other circumstances that preclude equipment operation in the area, the CONTRACTOR will install additional backup devices, as determined by the OWNER, by other appropriate methods. The CONTRACTOR will remove silt accumulations and deposit the spoils in an area approved by the OWNER as soon as practical. Any corrective action needed for the control measures will be accomplished in the sequence directed by the OWNER; however, areas adjacent to receiving waters shall generally have priority, followed by devices protecting storm sewer inlets.

In the event of conflict between these requirements and storm water pollution control laws, rules or regulations of other Federal, State, or Local agencies, the more restrictive laws, rules or regulations shall apply.

202.4.2. Other Practices and Controls. The CONTRACTOR shall also conform to the following practices and controls.

202.4.2.1. Location and Construction of CONTRACTOR'S Auxiliary Areas. Disposal areas, stockpiles, and haul roads shall be constructed in a manner that will minimize and control the amount of sediment that may enter receiving waters. Disposal areas shall not be located in any floodplain or receiving waters. Construction roads may not be located in or cross any receiving waters without prior approval of the OWNER and shall be done in compliance with applicable rules and regulations. Staging areas and vehicle maintenance areas shall be constructed by the CONTRACTOR in a manner to minimize the runoff of pollutants and at a location approved by the OWNER. The CONTRACTOR shall prevent pollution of receiving waters with petroleum products or other hazardous or regulated substances.

202.4.2.2. Activity In or Near Waters. Construction operations in receiving waters shall be restricted to those areas where it is necessary to perform the work shown on the plans. Wherever streams are crossed, temporary bridges, timber mats, or other structures shall be used and approved by the OWNER. When work areas or material sources are located adjacent to a receiving water, control measures such as diversion dikes or rock berms shall be used to keep sediment and other contaminants from entering the adjacent receiving water. Care shall be taken during the construction and removal of such barriers to minimize down-gradient sedimentation.

All receiving waters shall be cleared as soon as practicable of temporary embankment, temporary bridges, matting, falsework, piling, debris, or other obstructions placed during construction operations that are not a part of the finished work.

202.4.2.3. Materials Storage. Protected storage for paints, chemicals, solvents, fertilizers, and other potentially toxic materials will be provided by the CONTRACTOR at a location approved by the OWNER.

202.4.2.4. Vegetation. Disturbance of vegetation shall be minimized and limited to only what is shown on the construction plans or as directed by the OWNER in writing. Operations shall be in accordance with Item 204. Landscaping.

202.4.2.5. Keeping Roadways Clean. The CONTRACTOR shall clean paved surfaces, as necessary, to remove sediment that has accumulated on the roadway.

202.4.3. Cleaning and Stabilizing Project Area. The project will not be accepted until the CONTRACTOR has cleaned up as described in Item 107.25. Project Clean-up to the satisfaction of the OWNER. The project will

also not be accepted until the CONTRACTOR provides a uniform perennial vegetative cover with a density of 70-percent of the native background vegetative cover or, if in the opinion of the OWNER, permanent measures (such as riprap, gabions, geotextiles, or other stabilization methods approved by the OWNER), supplemented by temporary measures (such as mulching with seed, silt fences, earth dams, etc.) have been employed that will control erosion, sedimentation, and water pollution until sufficient vegetative cover can be established.

202.5. SILT FENCE

202.5.1. Description. Silt Fence is a barrier consisting of geotextile fabric, steel wire fence fabric and supported by steel posts to prevent soil and sediment loss from a site. This includes all labor and materials associated with installation, maintenance, and ultimate removal of the silt fence as shown in the construction drawings or similar document.

The purpose of a silt fence is to intercept and detain water-borne sediment from unprotected areas to a limited extent. Silt fence is used during the period of construction near the perimeter of a disturbed area to intercept sediment while allowing water to percolate through. This fence shall remain in place until the disturbed area is permanently stabilized. Silt fences are to be constructed along a line of constant elevation (along contour line) where possible. Silt fence shall not be used where there is a concentration of water in a channel or drainage way or where soil conditions prevent a minimum toe-in depth of 6-inches or installation of support post to depth of 12-inches. If concentrated flow occurs after installation, corrective action shall be taken such as placing a stone overflow in the areas of concentrated flow or replacing the silt fence with a more appropriate control measure.

202.5.2. Materials.

202.5.2.1. Geotextile. Silt Fence fabric must meet the following minimum criteria:

(1) Tensile Strength, ASTM D4632 Test Method for Grab Breaking Load and Elongation of Geotextiles, 90-lbs.
(2) Puncture Rating, ASTM D4833 Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products, 60-lbs.
(3) Mullen Burst Rating, ASTM D3786 Standard Test Method for Hydraulic Bursting Strength of Textile Fabrics-Diaphragm Bursting Strength Tester Method, 280-psi.
(4) Apparent Opening Size, ASTM D4751 Test Method for Determining Apparent Opening Size of a Geotextile, U.S. Sieve No. 40 (max) to 80 (min).
(5) Ultraviolet Resistance, ASTM D4355 standard Test Method for Deterioration of Geotextiles by Exposure to light, Moisture, and Heat in a Xenon Arc Type Apparatus, Minimum 70 percent.

202.5.2.2. Posts. Fence posts shall be steel and may be T-section or L-section, 1.3 pounds per linear foot minimum, and 4 feet in length minimum. Plastic caps to be installed in areas exposed to pedestrian traffic. Wood posts may be used if anticipated length of service is less than 90 days and provided they are 4 feet in length minimum and have a nominal cross section of 2 inches by 4 inches for pine or 2 inches by 2 inches for hardwoods. If allowed, wood posts shall be replaced if deterioration renders post ineffective.

202.5.2.3. Wire Support. Silt fence shall be supported by steel wire fence fabric as follows:

(1) 4" x 4" mesh size, W1.4 /1.4, minimum 14-gauge wire fence fabric;
(2) Hog wire, 12 gauge wire, small openings installed at bottom of silt fence;
(3) Standard 2" x 2" chain link fence fabric; or
(4) Other welded or woven steel fabrics consisting of equal or smaller spacing as that listed herein and appropriate gauge wire to provide support.

202.5.2.4. Stone. When a stone overflow is specified, the stone shall be 1½-inches washed stone containing no fines meeting the requirement for coarse crushed stone in Section 504.2.2.1. (a) Coarse Crushed Stone Embedment.

202.5.3. Construction. Silt Fence shall consist of synthetic fabric supported by wire mesh and steel posts set a minimum of 1-foot depth and spaced not more than 6-feet on center. A 6-inch wide trench is to be cut 6-inches deep at the toe of the fence to allow the fabric and wire mesh to be laid below the surface and backfilled with compacted earth or gravel. This entrenchment prevents any bypass of runoff under the fence. Fabric shall overlap at abutting ends a minimum of 3-feet and shall be joined such that no leakage or bypass

occurs. Sufficient room for the operation of sediment removal equipment shall be provided between the silt fence and other obstructions in order to properly maintain the fence. The last 10 feet (or more) at the ends of a line of silt fence shall be turned upslope to prevent bypass of stormwater. Additional upslope runs of silt fence may be needed every 200 to 400 linear feet, depending on the traverse slope along the line of silt fence. A stone overflow structure constructed in accordance with Standard Drawing 1020A shall be installed at all low points or spaced approximately every 300 feet if there is no apparent low point.

202.6. INTERCEPTOR SWALE

202.6.1. Description. A temporary interceptor swale may have a V-shape, parabolic, or be trapezoidal with a flat bottom. Interceptor swales are used to shorten the length of exposed slope by intercepting runoff and can also serve as perimeter swales preventing off-site runoff from entering the disturbed area or prevent sediment-laden runoff from leaving the construction site or disturbed area. The outlet (discharge point) of the swale shall be designed to have non-erosive velocities or designed with velocity dissipation devices. Diverted runoff from a disturbed area or other construction activity shall be conveyed to a sediment control. The swales shall remain in place until the disturbed area is permanently stabilized.

202.6.2. Applications and Design Criteria. It is the responsibility of the OWNER to provide specific details and specifications of all interceptor swales.

202.7. DIVERSION DIKE

202.7.1. Description. A temporary diversion dike is a barrier created by the placement of an earthen embankment to reroute the flow of runoff to an erosion control device or away from an open, easily erodible area. A diversion dike intercepts runoff from small upland areas and diverts it away from exposed slopes to a stabilized outlet or sediment trapping device. Dikes are generally used for the duration of construction to intercept and reroute runoff from disturbed areas to prevent excessive erosion until permanent drainage features are installed and/or slopes are stabilized. The outlet (discharge point) of the diversion dike shall be designed to have non-erosive velocities or designed with velocity dissipation devices. Diverted runoff from a disturbed area or other construction activity shall be conveyed to a sediment control.

202.7.2. Materials. For grades less than 2 percent and velocities less than 6 feet per second, the minimum required channel stabilization shall be grass, erosion control blankets, or anchored mulch. For grades in excess of 2 percent or velocities exceeding 6 feet per second, stabilization is required in the form of turf reinforcement mats (or rip-rap with appropriate size, gradation, and thickness depending on flow conditions). Velocities greater than 8 feet per second will require approval by the OWNER. Dike material shall consist of in situ soils with a plasticity index greater than 25.

202.7.3. Construction and Maintenance. Diversion dikes shall be installed prior to and maintained for the duration of construction and should intercept no more than 5-acres of runoff. Maximum depth of flow at the dike shall be 1 foot based on a 2-year return period design storm peak flow. Dikes shall have a minimum top width of 2.0-ft. and a minimum height of compacted fill of 18" measured from the top of the existing round at the upslope toe to top of the dike and having side slopes of 3:1 or flatter. The soil for the dike shall be placed in lifts of 8" or less and be compacted to 95-percent standard proctor density using ASTM D698 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort. The channel formed by the dike must have positive drainage for its entire length to a controlled outlet.

CONTRACTOR shall inspect dikes on a regular basis, at least as frequently as required by the SWPPP. Deficiencies shall be repaired as required by the SWPPP or as directed by the OWNER. Remove temporary diversion dike at direction of OWNER or upon establishment of permanent ground cover; and establish permanent ground cover in the area disturbed by the removal.

202.8. TRIANGULAR SEDIMENT FILTER DIKE

202.8.1. Description. The work shall consist of installing a temporary triangular sediment filter dike as shown on the plans during the construction period to control sedimentation.

The purpose of a triangular sediment filter dike is to intercept and detain water-borne sediment from unprotected areas of limited extent. Triangular filter dikes are used in place of silt fence, treating sediment flow at the perimeter of construction areas and at the perimeter of the site. Also, the dikes can serve as

stream protection devices by preventing sediment from entering the streams. This measure can be effective on paved areas where installation of silt fence is not possible.

202.8.2. Materials.

202.8.2.1. Geotextile. The fabric must meet the following minimum criteria:

(1) Tensile Strength, ASTM D4632 Test Method for Grab Breaking Load and Elongation of Geotextiles, 90-lbs.
(2) Puncture Rating, ASTM D4833 Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products, 60-lbs.
(3) Mullen Burst Rating, ASTM D3786 Standard Test Method for Hydraulic Bursting Strength of Textile Fabrics-Diaphragm Bursting Strength Tester Method, 280-psi.
(4) Apparent Opening Size, ASTM D4751 Test Method for Determining Apparent Opening Size of a Geotextile, U.S. Sieve No. 30 (max) to 100 (min).
(5) Ultraviolet Resistance, ASTM D4345 Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture, and Heat in a Xenon Arc Type Apparatus, Minimum 70 percent.

202.8.2.2. Wire Mesh Support. The internal support for the dike structure shall be 6-gauge 6" x 6" wire mesh or 4" x 4" welded wire fabric folded into triangular form being 18"on each side.

202.8.2.3. Filter Stone for Rock Bags. Material shall consist of 1inch Crushed Stone conforming to Item 504.2.2.1. Crushed Stone Embedment.

202.8.2.4. Bag Material for Rock Bags. Bag material shall be polypropylene, polyethylene, polyamide or cotton burlap woven fabric, minimum unit weight 4-ounces-per-square-yard, mullen burst strength exceeding 300-psi as determined by ASTM D3786 Standard Test Method for Hydraulic Bursting Strength of Textile Fabrics-Diaphragm Bursting Strength Tester Method, and ultraviolet stability exceeding 70-percent. Bag material shall be free of all defects.

202.8.3. Construction. Triangular sediment filter dikes shall be installed across exposed slopes during construction with ends of the dike tied into existing grades to prevent failure. Filter material shall lap over ends 6-inches to cover dike-to-dike junction; each junction shall be secured by shoat rings. Where the dike is placed on pavement, two rock bags shall be used to anchor the overlap to the pavement. Additional bags shall be used as needed to ensure continuous contact with the placement (no gaps). The ends of the dike shall be turned upgrade to prevent bypass of stormwater.

202.9. CHECK DAM (ROCK)

202.9.1. Description. The work shall consist of constructing temporary rock check dams as shown on the plans during the construction period to control erosion and sedimentation.

202.9.2. Materials.

202.9.2.1. Stone. Stone shall be well graded with size range from 1½-inches to 3½-inches in diameter depending on expected flows. Where the channel design flow velocity will be greater than 5 feet per second the upper size limit of the stone will need to be increased by the designer and specified on the construction drawings.

202.9.2.2. Geotextile Fabric. Use geotextile filter fabric under check dams exceeding 18 inches in height. If required, the check dam shall be placed on geotextile fabric meeting the following minimum criteria:

(1) Tensile Strength, ASTM D4632 Test Method for Grab Breaking Load and Elongation of Geotextiles, 250-lbs
(2) Puncture Rating, ASTM D4833 Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products, 135-lbs.
(3) Mullen Burst Rating, ASTM D3786 Standard Test Method for Hydraulic Bursting Strength of Textile Fabrics-Diaphragm Bursting Strength Tester Method, 420-psi.

Apparent Opening Size, ASTM D4751 Test Method for Determining Apparent Opening Size of a Geotextile, U.S. Sieve No. 20 (max).

202.9.3. Construction and Maintenance. Check dams should be placed at a distance and height to allow small pools to form between each one. Typically, dam height should be between 12" and 36". Dams should be spaced such that the top of the downstream dam should be at the same elevation as the toe of the

upstream dam. Rock check dams should be triangular in cross section with slopes of 1:1 or flatter on the upstream side and 2:1 or flatter on the downstream side. The middle overflow section of the check dam shall be half the total depth of the channel.

The check dam shall be inspected regularly in accordance with the SWPPP. The check dams shall be reshaped or replaced as needed during inspection. When the silt reaches 1/3 the height of the berm or 1-foot, whichever is less, the accumulated silt shall be removed and disposed of at an approved site in a manner that will not contribute to additional siltation. The check dam shall be left in place until all upstream areas are stabilized and accumulated silt removed; removal shall be done by hand.

202.10. CHECK DAM (FILTER TUBE)

202.10.1. Description. The work shall consist of constructing temporary filter tube check dams as shown on the plans during the construction period to control channel velocity and erosion.

202.10.2. Materials.

202.10.2.1. Filter Tube. Filter tubes shall meet the material requirements of Item 202.18 Filter Tubes.

202.10.2.2. Stakes (Metal and Wood). Galvanized or painted steel stakes in studded “T” shape or punched “U” shape, minimum filter tube diameter of 18” and a weight of 1.25 pounds per linear foot minimum. Hardwood stakes or pressure treated wood stakes nominal 2”x2”x36” minimum dimensions.

202.10.2.3. Geotextile Fabric. Section held for future use.

202.10.3. Construction and Maintenance. Filter tube check dams should be placed at a distance and diameter (i.e. height) to allow small pools to form between each one. Typically, minimum tube diameter shall be 6”. The tubes should be spaced such that the top of the downstream tube should be at the same elevation as the toe of the upstream tube. The filter tube shall be placed in a bedding trench to ensure firm contact between the tube and ground.

The check dam shall be inspected regularly in accordance with the SWPPP. The check dams shall be reshaped or replaced as needed during inspection. When the silt reaches 1/3 the height of the berm or 1-foot, whichever is less, the accumulated silt shall be removed and disposed of at an approved site in a manner that will not contribute to additional siltation. The check dam shall be left in place until all upstream areas are stabilized and accumulated silt removed; removal shall be done by hand.

202.11. STABILIZED CONSTRUCTION EXIT

202.11.1. Description. The work shall consist of constructing a temporary stabilized construction in accordance with contract documents. The exit will consist of a pad of crushed stone placed on a geotextile filter cloth and remain in place for the duration of the construction period to facilitate the removal of sediment and other debris from construction equipment prior to exiting the construction site. This includes all labor and materials associated with installation, maintenance, and ultimate removal of the stabilized construction exit as shown in the construction drawings or similar document.

202.11.2. Materials.

202.11.2.1. Stone. Stone material shall consist of 3-inch to 5-inch minimum coarse aggregate and shall be placed in a layer of at least 6-inches thickness. No crushed concrete shall be allowed.

202.11.2.2. Geotextile. The geotextile fabric must meet the following minimum criteria:

(1) Tensile Strength, ASTM D4632 Test Method for Grab Breaking Load and Elongation of Geotextiles, 300-lbs.
(2) Puncture Strength, ASTM D4833 Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products, 120-lbs.
(3) Mullen Burst Rating, ASTM D3786 Standard Test Method for Hydraulic Bursting Strength of Textile Fabrics-Diaphragm Bursting Strength Tester Method, 600-psi.
(4) Apparent Opening Size, ASTM D4751 Test Method for Determining Apparent Opening Size of a Geotextile, U.S. Sieve No. 40 (max).

202.11.3. Construction and Use. A temporary stabilized construction exit shall be installed at any point where traffic will be leaving a construction site to or from a paved surface such as a street, alley, sidewalk or parking area. The purpose of a stabilized construction exit is to reduce or eliminate the tracking or flowing of sediment onto paved surfaces. The exit shall be properly graded, sloping away from offsite paved surfaces

or incorporate a drainage swale to prevent runoff from leaving the construction site. Avoid placing construction access at the lowest point on the construction site or on top of proposed utility lines. The minimum length shall be 50 feet. The minimum width shall be 20 feet for sites less than 5 acres and 30 feet for sites 5 acres and larger.

The stabilized construction exit shall be maintained in a condition that prevents tracking or flow of sediment onto paved surfaces. Periodic re-grading and top dressing with additional stone must be done to keep the efficiency of the exit from diminishing. The rock shall be re-graded when ruts appear. Additional rock shall be added when soil is showing through the rock surface.

Additional controls will be required if inspections reveal a properly installed and maintained exit, but tracking of soil outside the construction area is still evident. All sediment spilled, dropped, washed or tracked onto public rights of way shall be removed immediately by the CONTRACTOR. The use of water to wash sediment from streets is prohibited.

When necessary, vehicles must be cleaned to remove sediment prior to entrance onto paved roads, streets, or parking lots. When vehicular washing is required, it shall be done on a constructed wheel wash facility that drains into an approved sediment trap or sediment basin or other sedimentation/filtration device.

202.12. STONE OUTLET SEDIMENT TRAP

202.12.1. Description. A stone outlet sediment trap is an impoundment created by the placement of a stone embankment and filter stone to prevent soil and sediment loss from a site. The stone embankment may be confined within a gabion basket or chain link fence fabric or unconfined. This item includes all labor and materials associated with installation, maintenance and ultimate removal of the stone outlet sediment trap as shown in the construction drawings or similar document.

202.12.2. Materials.

202.12.2.1. Embankment Stone. The embankment stone shall be comprised of Type A Dry Riprap stone conforming to Item 803.3. Riprap and with a size range of 6 to 12 inches in diameter.

202.12.2.2. Filter Stone. The filter stone covering the upstream face of the 6 to 12 inch Riprap shall be 1inches washed stone containing no fines meeting the requirement for coarse crushed stone in Section 504.2.2.1., Crushed Stone Embedment.

202.12.2.3. Geotextile. The embankment stone shall be place on geotextile fabric meeting the following minimum criteria:

(1) Tensile Strength, ASTM D4632 Test Method for Grab Breaking Load and Elongation of Geotextiles, 250-lbs.
(2) Puncture Rating, ASTM D4833 Test Method for Index Puncture Resistance of Geotextiles, Geomembranes, and Related Products, 135-lbs.
(3) Mullen Burst Rating, ASTM D3786 Standard Test Method for Hydraulic Bursting Strength of Textile Fabrics-Diaphragm Bursting Strength Tester Method, 420-psi.
(4) Apparent Opening Size, ASTM D4751 Test Method for Determining Apparent Opening Size of a Geotextile, U.S. Sieve No. 20 (max).

202.12.2.4. Confinement. When a confined stone outlet sediment trap is used the confinement of the embankment stone shall be by one of the following:

(1) Gabion Basket – Gabion baskets shall meet the requirements of Item 803.2.2.1. Baskets, Metallic Coated. Tie wire shall be supplied by the gabion manufacturer for use with the product selected.
(2) Chain Link Fence Fabric – Fabric shall meet the requirements of Item 801.4.2.1. Chain Link Fence Fabric, Zinc or Aluminum coated. Tie wire or metal bands for closure and anchoring shall be as recommended by the fabric supplier for use with the fence material used.

202.12.2.5. Anchor Pipe. Standard weight, 2” nominal diameter galvanized steel pipe.

202.12.3. Construction and Maintenance. The required temporary storage volume behind the stone outlet structure as shown on the construction plans shall be provided with the existing topography or can be provided by additional excavation as needed. Embankment slopes of excavated area should not be steeper than 2H: 1V to prevent slope failures into the storage area.

202.12.3.1. Stone Embankment. The maximum stone embankment height shall be 6 feet as measured from the toe of the slope on the downstream side. The minimum width of the stone

embankment at the top shall be 2 feet. Embankment slope shall be 1.5H: 1V or flatter. The embankment shall have a depressed area to serve as the overflow with a minimum width of 4 feet. The overflow width shall be designed to have a minimum freeboard of 6" at design flow.

For a confined stone outlet sediment trap the embankment stone may be enclosed in a gabion basket or chain link fence fabric and anchored to the channel bottom to prevent washing away. This type of device shall be required where the placement will be in a perennial stream channel.

202.12.3.2. Filter Stone Embankment Face. Filter stone shall be placed on the upstream face of the stone embankment to a minimum depth of 6 inches.

202.12.3.3. Maintenance. The filter stone on the upstream face shall be removed and replaced when it becomes clogged with any material that prevents the storage basin from dewatering. Also, accumulated silt shall be removed from the storage area when the depth of sediment is equal to one-third of the height of the embankment as measured from the original toe of slope to the crest of the outlet, or has reached a depth of one foot, whichever is less.

202.13. PIPE SLOPE DRAIN

202.13.1. Description. A temporary pipe slope drain is an erosion control device that combines an earthen diversion dike and a rigid or flexible pipe to carry runoff over an exposed slope to a stabilized outlet apron. This includes all labor and materials associated with installation and maintenance of the pipe slope drain as shown in the construction drawings or similar document. Maximum drainage areas for individual pipe slope drains shall be 5 acres. For areas larger than 5 acres, additional drains shall be added. Both the entrance and outfall of the pipe slope drain should be properly stabilized. Grass can normally be used at the entrance, but armor type stabilization such as stone or concrete riprap is normally required to address the high velocities of the outfall.

202.13.2. Materials.

202.13.2.1. Pipe. The drain pipe shall be made of any material, rigid or flexible capable of conveying runoff. Regardless of material, the drain pipe shall be completely water-tight so that no water leaks onto the slope to be protected.

202.13.2.2. Stabilized Outlet. The most common stabilized outlet consists of well graded stone or recycled concrete riprap. Alternate materials for stabilized outlets may be approved by the OWNER.

202.13.2.3. Stabilized Entrance. Material shall be in accordance with Item 202.15 Erosion Control Blankets.

202.13.2.4. Diversion Dike. Material shall be in accordance with Item 202.7 Diversion Dike.

202.13.3. Construction and Maintenance.

202.13.3.1. Pipe Slope Drain. A diversion dike shall be constructed at the top of the slope which shall be protected. Attached to the inlet end of the pipe, using water-tight fittings, shall be a standard tee fitting with a stabilized entrance apron extending a minimum of 3 feet long by 3 feet wide from the open ends of the tee staked in place per the manufacturer's recommendations. Attached to the branch end of the tee fitting shall be rigid or flexible pipe to be used for containment of the runoff from the top of the slope to the bottom. The pipe shall be secured with hold down anchors spaced 10 feet on center.

202.13.3.2. Stabilized Outlet. A stabilized outlet shall be excavated to accept the runoff from the pipe and dissipate the energy of the flow.

202.13.3.3. Maintenance. Pipe slope drains should be inspected regularly (at least as often as required by the SWPPP Construction General Permit) to locate and repair any damage to joints or clogging of the pipe. In cases where the diversion dike has deteriorated around the entrance of the pipe, it may be necessary to reinforce the dike with sandbags or to install a concrete collar to prevent failure. Signs of erosion around the pipe drain should be addressed by stabilizing the area with erosion control blanket, turf reinforcement mats, riprap, concrete, or other acceptable methods. All repairs shall be completed in a timely manner or as directed by the OWNER.

202.14. INLET PROTECTION

202.14.1. Description. Inlet protection devices vary depending on the type of inlet and whether the inlet is located at grade (i.e. on a slope) or in a sag (i.e. at a low point). The devices are normally located at the inlet, providing either detention or filtration to reduce sediment and floatable materials in storm water. Clogging can greatly reduce or completely stop the flow into the inlet.

Ensure that inlet protection is properly designed, installed and maintained to avoid flooding of the roadway or adjacent properties and structures. Inlet protection devices shall provide overflow capability to allow stormwater overflow during extreme storm events or when the filter media on the protection device has clogged. Inlet protection **shall not** be installed on inlets located on publicly traveled streets unless approved by the OWNER in writing.

The five types of inlets commonly used in public works construction are listed below with their recommended inlet protection devices. Grate inlets are installed in either paved or unpaved locations and they are therefore listed twice in the list below. These measures include all labor and materials associated with installation, maintenance and ultimate removal of the inlet protection as shown in the details or the approved construction drawings.

202.14.1.1. Curb Inlets.

A. Filter Tube – The use of a prefabricated or site fabricated filter tube and support system at the inlet to slow the sediment laden stormwater to allow sedimentation to occur. The diameter or height of the filter tube shall be two inches shorter than the curb opening height to allow for overflow capability.

B. Filter Fabric – The use of a geosynthetic filter fabric material and support system at the inlet to slow the sediment laden stormwater to allow sedimentation to occur. A 2-inch high gap shall be cut in the filter fabric just below the top of the curb opening to allow for overflow capability. The filter fabric and support system are held in place with filter stone anchor bags strategically placed to hold the filter fabric in contact with the pavement surface and the curb face.

202.14.1.2. Grate Inlets in Paved Areas.

A. Filter Tube – The use of a prefabricated or site fabricated filter tube at the inlet to slow the sediment laden stormwater to allow sedimentation to occur. The diameter or height of the filter tube shall be designated on the approved construction plans and shall be small enough to prevent flood damage to on site facilities or adjacent properties. Traffic control warning devices shall be provided to prevent damage from and to vehicles.

B. Block & Gravel – The use of filter stone with a concrete block and hardware fabric support system to slow the sediment laden stormwater to allow sedimentation to occur.

202.14.1.3. Grate Inlets or Area Inlets in Unpaved Areas.

(1) Filter Tube – The use of a prefabricated or site fabricated filter tube surrounding the inlet to slow the sediment laden stormwater to allow sedimentation to occur. The diameter or height of the filter tube shall be designated on the approved construction plans and shall be small enough to prevent flood damage to on site facilities or adjacent properties. The filter tube shall be located in a prepared bedding trench to ensure good contact with the underside of the filter tube and shall be staked in place to prevent movement by flowing stormwater.

(2) Block & Gravel – The use of filter stone with a concrete block and hardware fabric support system to slow the sediment laden stormwater to allow sedimentation to occur.

(3) Excavated Impoundment – The use of an excavated impoundment at the inlet to slow the sediment laden stormwater to allow sedimentation to occur. Dewatering weep holes shall be provided in the structure walls at the bottom of the excavation to allow the impoundment to dewater after rain events.

(4) Filter Fabric – The use of filter fabric with wire backing supported by wooden stakes at each corner of the grate and reinforced with a 2”x4” wood frame around the top perimeter of the wood posts.

202.14.1.4. Combination Inlets.

(1) Filter Tube – The use of a prefabricated or site fabricated filter tube at the inlet to slow the sediment laden stormwater to allow sedimentation to occur. The diameter or height of the filter tube shall be

designated on the approved construction plans and shall be small enough to prevent flood damage to on site facilities or adjacent properties. Traffic control warning devices shall be provided to prevent damage from and to vehicles.

202.14.1.5. Pipe Inlets.

(1) Filter Tube – The use of a prefabricated or site fabricated filter tube and support system at the inlet end of an open pipe system to slow the sediment laden stormwater to allow sedimentation to occur. The diameter or height of the filter tube shall be one half the diameter of the pipe opening to allow for overflow capability.

(2) Filter Stone – The use of a confined or unconfined stone dam with a six inch thick layer of filter stone on the upstream face of the stone dam to slow the sediment laden stormwater to allow sedimentation to occur. The height of the stone dam shall be one half the diameter of the pipe opening to allow for overflow capability.

202.14.2. Materials.

202.14.2.1. Filter Tubes. Filter tubes shall meet the material requirements of Item 202.18 Filter Tubes.

202.14.2.2. Concrete Blocks. Concrete blocks shall be standard 8" x 8" x 16" hollow core concrete masonry units and may be either load bearing or non-load bearing concrete masonry units.

202.14.2.3. Geotextile Filter Fabric. The fabric shall meet the material requirements of Item 202.5 Silt Fence.

202.14.2.4. Filter Stone. Filter stone shall consist of 1-1/2 inch Coarse Crushed Stone conforming to Item 504.2.2.1. Crushed Stone Embedment. Angular shaped stone is preferable to rounded shapes.

202.14.2.5. Stakes (Metal and Wood). Galvanized or painted steel stakes in studded “T” shape or punched “U” shape, minimum 36” long and a weight of 1.25 pounds per linear foot minimum. Hardwood stakes or pressure treated wood stakes nominal 2”x2”x36” minimum dimensions.

202.14.2.6. Wire Mesh. Wire mesh shall be standard hardware cloth or comparable wire mesh with an opening size not to exceed ½-inch.

202.14.2.7. Stone Riprap. The stone riprap shall be comprised of Type A Dry Riprap stone conforming to Item 803.3. Riprap with a size range of 6 inches to 12 inches in diameter.

202.14.3. Construction and Maintenance. Inlet protection filter media shall be placed to intercept the flow of sediment laden water into the inlet with no gaps and shall be adequately anchored to prevent movement. When properly installed the inlet filter media will pond water during a rain event and for up to two days after the end of the rain event. If the filter media becomes clogged and will not drain, remove the standing water through another sediment control BMP before it is allowed into the storm drain or off site. **Do not remove the filter media to allow the water to drain.** Replace the filter media with new material prior to the next rain event.

Check inlet protection devices for proper construction immediately after installation, at the end of each work day, immediately prior to rain events and as required by the SWPPP. Remove trapped sediment, floatable debris and yard waste as needed to keep the filter media clear.

202.14.3.1. Curb Inlets. The filter media shall make firm contact with the pavement surface at all times, shall extend beyond the curb opening at least 24 inches along the curb and be pressed tight against the curb face on both sides of the inlet opening. The overflow gap shall be provided to prevent complete blockage of the inlet opening.

202.14.3.2. Grate Inlets in Paved Areas. The filter media shall completely surround the grate inlet with no gaps and shall make firm contact with the pavement surface at all times. The height of the filter media surrounding the grate inlet shall be shown on the approved plans and must be checked on site to ensure that when water attains the top height of the filter media it will not cause localized flooding or property damage. Grate inlets are commonly located in the middle of paved areas subject to local and construction traffic. Installations shall have adequate traffic control devices to prevent damage to vehicles and to prevent damage to the BMP.

202.14.3.3. Grate Inlets & Area Inlets in Unpaved Areas. The filter media shall completely surround the inlet with no gaps and shall make firm contact with the ground surface at all times. A bedding trench

shall be provided under filter tubes when they are used. The height of the filter media surrounding the inlet shall be shown on the approved plans and must be checked on site to ensure that when water attains the top height of the filter media it will not cause localized flooding or property damage.

202.14.3.4. Combination Inlets. The filter media shall surround the three non-curb sides of the grate, extend beyond the curb opening at least 24 inches along the curb and be pressed tight against the curb face on both sides of the inlet opening.

202.14.3.5. Pipe Inlets. The filter media shall surround the pipe opening inlet as shown on the approved plans for project. A bedding trench shall be provided under filter tubes when they are used.

202.15. EROSION CONTROL BLANKETS

202.15.1. Description. An erosion control blanket (ECB) is a temporary erosion prevention product placed over disturbed areas to limit the effects of erosion due to rainfall impact and runoff across barren soil. Erosion control blankets are manufactured by a wide variety of vendors addressing a wide variety of conditions such as slope and functional longevity. Blankets are typically constructed of natural materials such as coir (coconut husk) fibers, excelsior (wood) or straw between two layers of synthetic netting.

202.15.2. Materials.

202.15.2.1. Blanket. Erosion control blanket shall be of a type and class appropriate to site-specific requirements as determined by the OWNER. Installed materials shall meet the applicable "Minimum Performance Standards for TxDOT" as published by TxDOT in its "Erosion Control Report". Approved products may be found in the official listing on the most current annual "Approved Products List for TxDOT" applicable to TxDOT Item 169 Soil Retention Blanket and its Special Provisions.

202.15.2.2. Staples. Staples shall conform to the recommendations shown within the manufacturer's published literature for the approved soil retention blanket. In the absence of manufacturer's recommendation for staples, a minimum 11-gauge wire staples 6-inches in length and 1-inch in width shall be used.

202.15.3. Construction and Maintenance.

202.15.3.1. Erosion Control Blanket. Prior to the installation of any erosion control blankets, all rocks, dirt clods, stumps, roots, trash and any other obstructions that would prevent the mat from lying in direct contact with the soil shall be removed. Anchor trenching shall be located along the entire perimeter of the installation area, except for small areas with less than 2% slope. These trenches shall be 6-inches deep and 6-inches wide and the blanket shall be laid into the trench then backfilled with compacted soil or gravel. At a minimum, the end of each roll of ECB shall overlap the next roll by 3 feet and the sides of rolls shall overlap 4 inches. Blankets shall be fastened to the ground according to the manufacturer's instruction. Staples shall be placed parallel to the flow, at all critical channel points, and at all overlaps. If requested by the OWNER, the CONTRACTOR shall submit staple pattern to the OWNER for approval. Installations shall be in accordance with manufacturer's recommended guidelines with the exception of the minimum criteria stated herein.

202.15.3.2. Maintenance. Blankets shall be inspected for deficiencies every seven days and after each half-inch or greater rainfall event. Noted deficiencies shall be repaired or replaced prior to the next rainfall event, but no later than seven days.

202.16. SECTION HELD FOR FUTURE USE

202.17. SECTION HELD FOR FUTURE USE

202.18. FILTER TUBES

202.18.1. Description. The work shall consist of constructing temporary filter tubes consisting of a filter media confined within a roll or tube of mesh material. The filter tube is then anchored or secured to the ground or pavement surface to prevent movement during storm events. The filter tube slows the flow of

sediment laden stormwater to allow the sediment to settle out or to be filtered out as the stormwater seeps through the filter media. Installations are either for perimeter protection or slope protection.

202.18.2. Materials.

202.18.2.1. Tubes. Tubes shall be constructed out of geosynthetic material, plastic mesh, jute mesh, coir mesh or metal hardware fabric. Material used shall be of adequate strength and durability to withstand anticipated environmental conditions (Heat, cold, ultraviolet light, etc.) and construction hazards during the full term of the device installation. The mesh openings shall be large enough to allow the flow of water through the filter media, but will be small enough to contain the filter media.

202.18.2.2. Filter Media. Filter media may consist of any of the following or an approved combination of the following materials:

(1) Compost. Erosion Control Compost (ECC) per TxDOT Specification Item 161, Compost.
(2) Coir or Straw. Commercially produced product interwoven into the tube mesh. Loose material inserted into the tube will not be allowed.
(3) Filter Stone. Stone shall consist of 1-1/2 inch Coarse Crushed Stone conforming to Item 504.2.2.1. Crushed Stone Embedment.

202.18.2.3. Stakes. Stakes may be metal or wood. Metal stakes when used will be T-section or L-section and 1.3 pounds per linear foot minimum. Wood stakes when used shall have a nominal cross section of 2-inches by 2-inches. Stakes shall be at least six inches longer than the outside diameter of the tube being anchored.

202.18.3. Construction and Maintenance. Installations shall be of the size and material specified on the approved plans or as approved by the OWNER. Overlaps between ends of bound or sealed tubes shall be a minimum of three feet and shall be securely tied together to prevent gaps from forming between the tubes and movement of the tubes. Filter Tubes are to be placed along a line of constant elevation (along a contour line) where possible. The ends of the tube installation at the edge of the disturbed ground area shall be turned uphill to prevent the bypass of stormwater.

202.18.3.1. Perimeter Protection. For installations on soil, construct a one-inch to two-inch deep shaped bedding trench along the full length of the filter tube to ensure positive contact of the filter tube with the soil. Install the properly sized filter tube at the downstream edge of the disturbed land area and anchor in place with stakes placed on maximum eight-foot centers. For installations on pavement which typically occur along utility trenches or when there is a temporary stockpile of erodible material, the mesh with the filter media in place shall provide at least a 6-inch wide contact with the pavement to ensure that the stormwater flows through the filter media. The filter tube shall be anchored with temporary traffic control devices (i.e. vertical panel, barrels, etc.) or standard concrete masonry units to prevent movement of the filter tube during storm events.

202.18.3.2. Slope Protection. Slope protection installations are generally only installed when slopes are steeper than 5H: 1V, slopes that are longer than 30’ from top to bottom, or the slope has a large amount of stormwater runoff that will flow downslope. Filter tubes shall be placed at the spacing shown on the approved plans, but generally every 25’ apart along lines of constant elevation.

202.19. MEASUREMENT AND PAYMENT

If included in the Contract as a unit price item, measurement for payment will be made complete, in place and ready for use inclusive of all components necessary for a complete and working installation. This includes all labor and materials associated with installation, maintenance, and ultimate removal as shown in the construction drawings or similar document, and establishing permanent ground cover at removal.

ITEM 203. SITE PREPARATION

203.1. GENERAL SITE PREPARATION

203.1.1. Description. This Item shall consist of preparing the right-of-way and designated easements for construction operations by the removal and disposal of all obstructions from the right-of-way and from designated easements, where removal of such obstructions is not otherwise provided for in the plans and specifications. Such obstructions shall be considered to include remains of houses not completely removed by others, foundations, floor slabs, concrete, brick, lumber, plaster, septic tanks, basements, abandoned utility pipes or conduits, equipment or other foundations, fences, retaining walls, outhouses, shacks and other debris.

This item shall also include the removal and disposal of curb and gutters, driveways, paved parking areas, miscellaneous stone, brick, concrete sidewalks, drainage structures, manholes, inlets, abandoned railroad tracks, scrap iron, all rubbish and debris, whether above or below ground except live utility facilities. This Item shall also include the removal and disposal of designated trees, stumps, bushes, vegetation, roots, shrubs, brush, and logs. It is the intent of this specification to provide for the removal and disposal of all obstructions and objectionable materials not specifically provided for elsewhere in the plans and specifications. This Item does not include the removal and disposal of hazardous material.

203.1.2. Construction Methods.

The entire right-of-way, permanent and temporary easements for this project and such additional areas, including public or corporate areas and public or corporate lands, as made available for construction of this project, shall be cleared of all structures and obstructions, as defined above, except that trees or shrubs shall be protected unless specifically designated by the OWNER for removal. Unless designated for removal without replacement, trees and shrubs shall be treated according to Item 201.1. Removal, Protection, and Replacement of Trees, Shrubbery, Plants, Sod, and Other Vegetation. Unless otherwise indicated on the plans, trees and stumps to be removed shall be cut off or otherwise removed as close to the natural ground as practicable on areas which are to be covered by at least 3-ft. of embankment. On areas required for borrow sites and material sources, stumps, roots, etc., shall be removed to the complete extent necessary to prevent such objectionable matter becoming mixed with the material to be used in construction. At all times during site preparation, the area shall be maintained in a manner as to prevent standing water.

Unless otherwise indicated on plans, all foundations and underground obstructions shall be removed to the following depths:

(1) In areas to receive embankment, 2-ft. below natural ground or to bottom of structure.
(2) In areas to be excavated, 2-ft. below the lower elevations of the excavation, or to the bottom of structure.
(3) In all other areas, 1-ft. below natural ground or to bottom of structure.

All basement walls and floors, septic tanks and storage tanks within the limits of the right-of-way shall be removed and the resulting holes backfilled as directed by the OWNER. Holes remaining after removal of all obstructions, objectionable material, trees, stumps, etc., shall be backfilled. The CONTRACTOR shall complete the operation of preparing right-of-way so that the prepared right-of-way shall be free of holes, ditches and other abrupt changes in elevations and irregularities to contour.

The remaining ends of all abandoned-in-place storm sewers, culverts, sanitary sewers, conduits and water or gas pipes shall be plugged with an adequate quantity of concrete to form a tight closure. All materials and debris removed shall become the property of the CONTRACTOR unless otherwise provided for on the plans or in the specifications and shall be removed from the right-of-way. Unless otherwise provided, all merchantable timber removed as previously specified shall become the property of the CONTRACTOR. Gravel, brick, stone or broken concrete, when permitted by special conditions, may be used in the roadway embankment.

203.1.3. Measurement and Payment. General site preparation shall be measured on a lump sum basis, unless indicated otherwise. Measurement for payment shall be made only on areas indicated and classified on the plans as “General Site Preparation,” and disposed of properly as indicated in Item 107.26. Disposal of Materials. All work performed and measured as prescribed by this Item shall be paid for at the lump sum

price bid for "General Site Preparation" unless indicated otherwise, which price shall be full compensation for furnishing all labor, equipment, tools, supplies and incidentals necessary to complete the work.

203.2. UNCLASSIFIED EXCAVATION

203.2.1. Description. Unclassified excavation shall consist of required excavation for general site grading, and street and channel excavation within the limits of the OWNER'S right-of-way or designated easements and areas adjacent thereto (except excavation specifically described and provided for elsewhere in the specifications). This will include the proper removal, utilization, and/or disposal of all uncontaminated excavated materials to the required lines, grades and typical cross sections in accordance with the plans and specifications.

203.2.2. Classification. All authorized excavation shall be "unclassified" and involves removal of all materials necessary to permit carrying on the completion of the work. Any reference to rock or other material on the plans and/or in this specification is solely for the OWNER'S and CONTRACTOR'S information and is not to be taken as an indication or guarantee of classification of excavation.

203.2.3. General. In general, all excavation shall be made in open cut from the surface of the ground and shall be no greater in width or depth than is necessary to permit the proper construction of the work in accordance with the plans and specifications. Where excavation to grades established in the field by the OWNER would terminate in unstable soil, the CONTRACTOR shall remove the unstable soil and backfill to the required grade. Work shall be executed in a neat workmanlike manner. All excavation shall be to the line and grade as provided on the approved plans. The CONTRACTOR shall abide by all applicable federal, state and/or local laws governing excavation work.

The CONTRACTOR shall provide for the uninterrupted flow of storm, water and wastewater lines and surface waters during progress of the construction. The CONTRACTOR shall coordinate interruptions to gas, electric, and other services no less than two (2) days prior to construction of the planned interruptions. Completed work shall conform to the established alignment, grades and cross sections.

203.2.4. Water for Construction. The CONTRACTOR shall provide water as needed for site preparation, compaction, and other incidental activities in accordance with local requirements.

203.2.5. Dewatering. During construction, channels, trenches, pits, and other low point excavations shall be kept drained, insofar as practicable. Dewatering work shall include the installation and operation of all pumping, bailing, well-pointing, sumps, and draining necessary to keep the excavation free from groundwater, seepage water, water from storm drains, wastewater collection systems, ditches, creeks, ponds, and other sources. Construction will not be permitted in standing water. All discharges from dewatering activities shall be in conformance with all federal, state, and local requirements in a manner approved by the OWNER. Outlet velocity of discharges from dewatering activities shall be controlled to prevent erosion. Unless provided for as a separate pay item, all dewatering work shall be considered incidental to unclassified excavation.

203.2.6. Excavated Material. Excavated materials shall be handled at all times in such manner as to cause a minimum of inconvenience to the public and to permit safe and convenient access to private and public property adjacent to the line of the work.

All suitable materials removed from the excavation shall be used, insofar as practicable, in the formation of embankments as required by Item 203.5. Embankment, or shall be otherwise utilized. Desirable topsoil, sod, etc. shall be carefully removed and piled separately adjacent to the work when required. Suitable excavated materials to be utilized for the project may be temporarily stockpiled adjacent to the work provided appropriate BMPs are installed.

Unclassified excavated material in excess of that needed for construction or deemed unsuitable shall be known as "waste" and, unless specified otherwise, shall become the property of the CONTRACTOR to be disposed of outside the limits of the project in accordance with federal, state, and local requirements.

203.2.7. Alternate Methods of Excavation. Prior to commencing any alternate method of excavation, the CONTRACTOR shall submit means and methods approach for approval by the OWNER. All alternate methods of excavation shall be in compliance with applicable federal, state, and local requirements. If approved by the OWNER, alternate methods of excavation shall be at no additional cost to the OWNER.

203.2.8. Measurement and Payment. All unclassified excavation shall be measured in its original position and the volume in cubic-yards determined by the average end area method. Work performed for finishing of parkways and medians shall not be measured directly, but shall be considered subsidiary to unclassified excavation.

All unclassified excavation work performed as prescribed by this Item shall be paid for at the contract bid price per cubic-yard for unclassified excavation, which price shall constitute payment in full for furnishing and operating all equipment, excavation, placement, compaction, loading, hauling, and unloading and for satisfactory disposal of unsuitable and excess materials; finishing slopes, ditches and parkways; for all maintenance blading or scarifying the ground surface; and for furnishing all labor, fuel, tools, materials, equipment, implements, and incidentals necessary to the satisfactory performance of the work.

203.3. SECTION HELD FOR FUTURE USE

203.4. BORROW & SPOIL

203.4.1. Description. Borrow shall consist of required excavation, removal, and proper utilization of materials obtained from designated or approved off-site sources. Spoil shall consist of the required excavation, removal, transportation, deposit, and storage of materials to an off-site location.

203.4.2. Classification. All authorized borrow shall be "unclassified" unless otherwise noted.

203.4.3. Construction Methods. All suitable materials removed from the excavation shall be used, insofar as practicable, in the formation of the embankment as required by the governing item for embankment; or shall otherwise be utilized as indicated on the plans or as directed. The completed work shall conform to the established alignment, grades and cross section. Site of the borrow and spoil operations shall be left so as to provide proper drainage where practicable. Where indicated on the plans, the sides and/or ends of borrow pits shall be sloped to the dimensions indicated on the plans.

203.4.4. Selection of Materials. Where shown on the plans, select material shall be utilized in the formation of embankment, embedment or backfill, or to improve the project, in which case the work shall be performed in such a manner and sequence that suitable material may be selected, removed separately and deposited in the project as shown on the approved plans. When required, acceptable borrow material, tested by standard laboratory methods, and shall meet the requirements indicated on the plans.

203.4.5. Measurement and Payment. Borrow shall be measured in a compacted condition in its final position and the volume computed in cubic-yards by the method of average end areas, or as specified otherwise. Spoil sites shall be considered part of the overall project site, and the spoil area shall contribute to the total project acreage.

All work performed as required herein and in the Item 203.5. Embankment, and measured as provided in this Item shall be paid for at the unit price bid. Payment shall not be allowed for excavation for any material which is used for purposes other than those designated. The unit price shall be full compensation for furnishing all labor, for materials, tools, equipment, compaction, hauling and incidentals necessary to compete the work, as well as for any and all fees associated with disposal.

203.5. EMBANKMENT

203.5.1. Description. Embankment shall consist of the placement and compaction of all suitable materials obtained from excavation, borrow or any other approved excavation.

203.5.2. Construction Methods. Prior to the placing of any embankment, all clearing and grubbing and site preparation shall have been completed. Stump holes or other small excavations within the limits of the embankment shall have been backfilled with material with same properties as to in-situ material or specified fill material before commencing the embankment construction. The surface of the ground, including plowed or loosened ground or small ditches or washes, shall be restored to approximately its original slope.

The surface of hillsides shall be loosened by the scarifying or plowing to a depth of not less than 4-in. or cut into steps before embankment materials are placed. The embankment shall then be placed in layers as hereinafter specified, beginning at the low side in part widths as the embankment is raised. The material

which has been loosened shall be recompacted simultaneously with the embankment material placed at the same elevation.

Where embankment is to be placed over or adjacent to the existing roadbeds, the slopes shall be plowed or scarified to a depth not less than 4-in. and the embankment built up in successive layers, as hereinafter specified, to the level of the old roadbed before its height is increased. Then the old roadbed shall be scarified and recompacted with the next layer of embankment. The total depth of the scarified and added materials shall not exceed the permissible depth of the layer. All embankments for roadbeds shall be constructed in layers approximately parallel to the finished grade of the street and shall be so constructed as nearly as possible to conform to the cross section of the subgrade section.

Embankments shall be constructed to the established grade and to the shape of the typical section shown on the plans, and each section shall conform to the detailed sections of slopes. After completion of the embankment, it shall be continuously maintained to its finished section and grade until the project is accepted.

Earth embankments shall be constructed in successive layers, for the full width of specified depth or cross sections; and in such lengths as are suitable for the sprinkling and compaction methods to be used. Each layer of earth embankment shall be uniform as to material, density, and moisture content before beginning compaction. Prior to compaction, the layers shall not exceed 6-in. in depth for pneumatic tire rolling or 8-in. in depth for rolling with other types of rollers unless otherwise specified on the plans.

Earth embankment for the construction of dams and placed adjacent to and over pipes, culverts, arches and bridges shall be of material as specified on the plans and shall be placed in successive layers approximately horizontal. Layers of embankment shall be brought up uniformly on each side of the structure, and special care shall be taken to prevent any wedging action against the structure. For such distances along embankments adjacent to structures where it is impracticable to obtain compaction by rolling, the embankment material shall be placed in layers not exceeding 6-in.in depth of loose material wetted uniformly to the moisture content directed; and shall then be compacted by methods approved by the OWNER, maintaining the required moisture content by additional sprinkling, if necessary, supplemented by such hand work as is necessary to secure a uniform and thoroughly compacted fill, until each layer has been uniformly compacted to the satisfaction of OWNER.

All earth cuts, full or part width in the side of a hill, which are not required to be excavated below subgrade elevation for base or backfill, shall be scarified to a uniform depth of not less than 6-in. below grade shown on the plans, and the materials shall be mixed and reshaped by blading and then sprinkled and rolled in accordance with the hereinabove outlined requirements for earth embankments.

Rock embankments shall be composed principally of rock and shall be constructed in successive layers for the full width of the specified depths or cross sections, and each layer shall be 18-in. or less in depth. Each layer shall be constructed by starting at one end, dumping the rock on top of the layer being constructed and then pushing the dumped material ahead in such a manner that the larger rock shall be placed on the ground or preceding rock embankment layer; and the interstices between the larger stones shall be filled with smaller stones and spalls both by this operation and from the placing of succeeding loads of rock materials. Each rock layer shall be rolled or compacted as specified in the plans. The upper or final layer of rock embankment shall contain no stones larger than 4-in. in their maximum dimension, and insofar as such is available by selection of the excavation, this layer shall be composed of materials so graded that the maximum density and uniformity of the surface layer may be secured. Each rock embankment layer shall be rolled as directed by the OWNER.

In addition to the foregoing selection of materials and utilization of the materials in the embankment, the embankment shall be constructed in the proper sequence to receive select materials as specified or as shown on the plans, with any modifications as may be directed by the OWNER. The layer of embankment immediately preceding the upper layer of select material shall be constructed to the required cross section and the proper elevation within a tolerance of not more than 0.1-ft. from the established cross section or elevation after proper compaction and shall be finished as necessary to receive the select material.

203.5.3. Density. For each layer of earth embankment and select material, the relative compaction of the embankment shall be as shown on the plans. Earth embedment and select material shall be compacted to between 95 percent and 100 percent of Standard Proctor Density as determined by ASTM D-698 at, or up to

five (5) percentage points above, optimum moisture content, using mechanical compaction methods, unless otherwise specified in the plans or specifications. After each section of earth embankment or select material is completed, such tests as are necessary shall be made as specified by the OWNER, unless otherwise specified in the special provisions or in the plans.

203.5.4. Measurement and Payment. Embankment shall not be measured or paid for as a separate contract pay item, but the cost of construction of the embankment complete in place shall be included in such contract pay items as described in standard specifications Item 203.2. Unclassified Excavation or Item 203.4. Borrow & Spoil. The contract pay items provided shall be full compensation for the furnishing of all labor, material, tools, equipment and incidentals necessary to complete the embankment, including cost of water, sprinkling or wetting, rolling, compaction, etc., in accordance with the plans and specifications.

203.6. DUST CONTROL

203.6.1. Description. Sprinkling for dust control shall consist of the authorized application of water or other material approved by the OWNER on those portions of the projects as shown on the plans or as directed and as herein specified. It shall be the responsibility of the CONTRACTOR to take preventive measures to eliminate, reduce, or alleviate any dust nuisance in the work area. The OWNER will approve the method used. Should the CONTRACTOR fail to control dust as outlined above, the OWNER may suspend the work until corrective measures are taken.

203.6.2. Materials. Water or other material approved by the OWNER shall be furnished by the CONTRACTOR and shall be clean, free from industrial waste and other objectionable matter. Emulsions shall meet the requirements of Item 302.3.4.5. Emulsions for Priming, Curing and Erosion Control.

203.6.3. Construction Methods. The CONTRACTOR shall use sprinkling or other methods acceptable to the OWNER to control dust in accordance with TCEQ airborne contamination requirements. When sprinkling, the CONTRACTOR shall furnish and operate a sprinkler equipped with positive and rapidly working cutoff valves and approved spray bars, which shall insure the distribution of material in a uniform and controllable rate of application.

The CONTRACTOR shall maintain all excavations, embankment, stockpiles, haul roads, and access roads within or outside the project boundaries free from dust, which would cause a hazard or nuisance to adjacent property owners. The CONTRACTOR shall effectively prevent and control erosion and sedimentation from any runoff resulting from dust control activities. It shall be the CONTRACTOR'S continuous responsibility to be on call at all times including nights, holidays, weekends, etc. and respond in a timely manner, until acceptance of the project by the OWNER, to maintain the project free of dust in a manner which shall cause the least inconvenience to the public.

203.6.4. Measurement and Payment. Sprinkling performed as provided above shall be measured by the 1,000-gallons as delivered on the project. Sprinkling provided in the proposal and the contract as a separate pay item shall be paid for in accordance with the contract unit price. Noncompliant dust control activities shall not be approved for payment by the OWNER. When sprinkling is not classified separately for payment, then such sprinkling shall be considered as incidental work and shall not be paid for as a separate item; the cost thereof shall be included in such contract pay items as are provided. In either case, such pay items shall be the total compensation for all labor, materials, tools, machinery, equipment and incidentals necessary to complete the work in accordance with the plans and this specification.

ITEM 301. SUBGRADE, SUBBASE, AND BASE PREPARATION

301.1. GENERAL

Subgrade is that portion of the roadbed upon which the subbase, base or the pavement is to be placed. It includes minimum 12-in. beyond the back of the curb for streets, which are to be paved with concrete. Subbase is that layer of specified material of plan thickness between a base and a subgrade. Base is that layer of specified material of plan thickness placed immediately below the pavement course surfacing.

301.1.1. Subgrade Preparation.

301.1.1.1. Description. These specifications shall govern for the preparation of the subgrade except as otherwise provided or specified.

301.1.1.2. Equipment. All equipment necessary for the construction of this item shall be on the project and shall be approved by the OWNER as to condition before the CONTRACTOR shall be permitted to begin construction operations on which the equipment is to be used. Any equipment that achieves the desired results in the time frame allowed is acceptable.

301.1.1.3. Construction Methods. After the excavation of embankment has been substantially completed, the subgrade shall be shaped so that after rolling as specified in Item 301.1.2. Rolling of Embankment, Subgrade or Flexible Base and subsequent finishing operations, it shall conform to the correct alignment, cross section and elevation. Subgrade shall be proof rolled prior to subgrade stabilization and after final compaction after subgrade stabilization as specified in Item 301.1.1.3.1. Proof Rolling. Rolling and sprinkling, as needed, shall be performed when and to the extent directed and the roadbed shall be completed to or above the plane of the typical section shown on the plans and the lines and grades established by the OWNER.

After completion of the compaction and immediately before the application of subbase, base or pavement, the subgrade preparation equipment shall be operated using approved methods in a manner to finish the subgrade to the required section. The subgrade shall then be tested with the approved template, operated and maintained by the CONTRACTOR. All irregularities which develop in excess of ½-in. in a length of 16-ft. measured longitudinally shall be corrected by loosening, adding or removing material; reshaping; and recompacting by sprinkling and rolling. The completed subgrade shall have a uniform density of not less than 95-percent of the maximum density determined by ASTM D698 Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lb/ft3). Moisture content shall be within minus-2- to plus-4-of-optimum.

The subgrade shall be maintained in a smooth, compacted condition, in conformity with the required section and established grade, until the subbase, base or pavement is placed, and shall be kept wetted down sufficiently in advance of placing any subbase, base or pavement to insure its being in a firm and moist condition for at least 2-in. below surface of the prepared subgrade. Only such subgrade as is necessary for the satisfactory execution of the work shall be completed ahead of the placement of base or pavement. Hauling or operating of unnecessary equipment on the completed subgrade shall be kept to a minimum. If equipment is operated on recent work, the OWNER may inspect and require subgrade replacement for such defects as fractures, rutting, or any other failure. Complete drainage of the subgrade shall be provided at all times.

Finishing of the subgrade by other methods shall be permitted on pavement widening projects, on sections where the pavement width is not uniform, at intersections and elsewhere where the operation of certain equipment would not be practical. Subgrade finished by hand or other methods shall conform to the requirements above specified. not be practical. Subgrade finished by hand or other methods shall conform to the requirements above specified.

301.1.1.3.1. Proof Rolling. This Item shall govern for furnishing and operating heavy pneumatic tire compaction equipment for locating unstable areas of earthwork or base.

301.1.1.3.1.1. Proof Rolling Equipment. The proof rolling equipment shall consist of not less than four pneumatic tire wheels, running on axles carrying not more than four wheels, and mounted in a rigid frame and provided with loading platform or body suitable for ballast loading.

All wheels shall be arranged so that they will carry approximately equal loads when operating on uneven surfaces.

The proof roller under working conditions shall have a rolling width of from 8-ft. to 10-ft., and shall be so designed that, by ballast loading, the gross load may be varied uniformly from 15 tons to 25 tons. The tires shall be capable of operating under the various loads with up to 150 pounds per square inch air pressure. Tires shall be practically full of liquid. (Tires shall be considered as being practically full when liquid will flow from the valve stem of a fully inflated tire with the stem in the uppermost position.)

The operating load and tire pressure shall be within the range of the manufacturer's chart as directed by the OWNER. The CONTRACTOR shall furnish the OWNER charts 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.

The proof roller shall be towed by a suitable crawler type tractor or rubber tire tractor of adequate tractive capacity, or may be of the self-propelled type. A proof roller unit shall consist of either a self-propelled roller or combination of roller and towing tractor.

There shall be a sufficient quantity of ballast available to load the equipment to a maximum gross weight of 25 tons.

Rubber tire tractive equipment shall be used on base courses and asphalt pavements. Other type tractive equipment may be used on embankment subgrade. The heavy pneumatic tire roller unit shall be capable of turning 180 degrees in the crown width or operating in forward and reverse modes.

In lieu of the rolling equipment specified, the CONTRACTOR may, upon written permission from the OWNER, operate other compacting equipment that will produce equivalent results in the same period of time as the specified equipment. The CONTRACTOR shall submit together with any proposed alternate compacting equipment, the weight (empty and with proposed loading), the wheel configuration and load distribution along with his proposed procedure to provide full width and length coverage of the subgrade area within the required period of time. If the substituted compaction equipment fails to produce the desired results within the same period of time as would be expected of the specified equipment, as determined by the OWNER, its use shall be discontinued.

301.1.1.3.1.2. Proof Rolling Construction Methods. This work shall be done when specified in the plans and specifications. The subgrade and base layer shall be proof rolled to locate unstable areas.

Within the ranges set forth in Item 301.1.1.3.1. Proof Rolling, the load and tire inflation pressures shall be adjusted as directed by the OWNER. It is proposed to use a contact pressure corresponding as nearly as practical to the maximum supporting value of the earthwork or base. A minimum of two coverages of the proof roller will be required. Each succeeding trip of the proof roller shall be offset by not greater than one tire width. Rollers shall be operated at speeds directed by the OWNER which shall be between 2 and 6 miles per hour.

Where the operation of the proof roller unit shows an area to be unstable or non-uniform, it shall be corrected in accordance with the applicable Item of Work.

301.1.1.4. Measurement and Payment. Preparation of subgrade shall not be measured for payment as a separate contract pay item. Preparation of the subgrade or fine grading shall not be paid for as a separate contract pay item; and cost thereof shall be included in such contract items as are provided, which pay items shall be the total compensation for the furnishing of all labor, tools, materials, equipment and incidentals necessary to complete the work, including disposal or surplus material, all in accordance with the plans and these specifications.

301.1.2. Rolling of Embankment, Subgrade or Flexible Base

301.1.2.1. Description. Rolling shall consist of the compaction of embankment, subgrade or flexible base by the operation of approved power rollers, as herein specified and as directed by the OWNER.

301.1.2.2. Roller Requirements. All equipment necessary for the construction of this item shall be on the project and shall be approved by the OWNER as to condition before the CONTRACTOR shall be permitted to begin construction operations on which the equipment is to be used. Any equipment that achieves the desired results in the time frame allowed is acceptable. If equipment fails to produce the desired result within the required time frame, its use shall be discontinued and the CONTRACTOR will be required to furnish equipment, as determined by the Engineer, at no additional cost to the OWNER.

Sufficient rollers shall be provided to compact the material in a manner satisfactory to the OWNER. When operations are so isolated from one another that one roller unit cannot perform the required compaction satisfactorily, the CONTRACTOR shall provide additional roller units.

301.1.2.3. Rolling Methods. The embankment, subgrade or base course shall be sprinkled as directed by the OWNER. Rolling patterns and speeds shall be established per project and indicated on the plans.

301.1.2.4. Measurement and Payment. Rolling provided in the proposal and contract, as a separate contract pay item, shall be measured for payment by the actual hours the roller is in operation, as ordered by the OWNER. Rolling provided in the proposal and the contract, as a separate pay item, shall be paid for in accordance with the contract unit price. When rolling is not classified separate for payment, then such rolling shall be considered as incidental work and shall not be paid for as a separate item. The cost thereof shall be included in such contract pay items as are provided. In either case, such pay items shall be the total compensation for all labor, materials, tools, machinery, equipment and incidentals necessary to complete the work in accordance with the plans and this specification.

301.2. LIME TREATMENT

This item shall consist of treating subgrade, subbase, and base courses by the pulverization, addition of lime, mixing and compacting the mixed material to the required density. This item applies to natural ground, embankment, or pulverized recycled asphalt pavement base or subbase courses placed under this contract, which shall be constructed as specified herein and in conformity with the typical section, lines and grades as shown on the plans.

301.2.1. Materials.

301.2.1.1. Hydrated Lime (Slurry).

301.2.1.1.1. General. Hydrated lime slurry shall be a pumpable suspension of solids in water. The solids portion of the mixture, when considered on the basis of “solids content,” shall consist principally of hydrated lime of a quality and fineness sufficient to meet the following requirements as to chemical composition and residue.

301.2.1.1.2. Chemical Composition. The “solids content” of the lime slurry shall have a hydrate alkalinity $Ca(OH)_2$ of not less than 90-percent by weight.

301.2.1.1.3. Residue. The percent by weight of residue retained in the “solid content” of lime slurry shall conform to the requirements in Table 301.2.1.1.3.(a) Hydrated Lime.

Table 301.2.1.1.3.(a) Hydrated Lime

Sieve Size	Residue Retained, Percent by Weight
No. 6 (3360 micron)	None
No. 10 (2000 micron)	Max. 1.0%
No. 30 (590 micron)	Max. 2.5%

301.2.1.1.4. Slurry Grades. Type B, commercial lime slurry, shall conform to one of the following three grades:

(1) Grade 1: The “dry solids contents” shall be at least 31-percent by weight of the slurry.
(2) Grade 2: The “dry solids contents” shall be at least 35-percent by weight of the slurry.
(3) Grade 3: The “dry solids contents” shall be at least 46-percent by weight of the slurry.

When Type B, commercial lime slurry, is specified, the CONTRACTOR shall select, prior to construction, the grade to be used and shall notify the OWNER in writing before changing from one grade to another.

301.2.1.2. Quicklime.

CAUTION: Handling and use of quicklime can be dangerous. Quicklime should be prescribed by a registered professional engineer familiar with its use.

301.2.1.2.1. General. Quicklime is a dry material consisting essentially of calcium oxide. It shall be furnished either in "pebble" gradation suitable for dry placing and slurry placing, or as a dry powder suitable only for slurry placing. Powdered quicklime is restricted to slurry placing, as the possibility of appreciable amounts of finely divided powdered quicklime makes it unsuitable for dry placing.

301.2.1.2.2. Chemical Composition. Quicklime shall conform to the chemical requirements of ASTM C977 Quicklime and Hydrated Lime for Soil Stabilization.

301.2.1.3. Tests. If the minimum design strength or percent lime to be used for the treated subgrade, existing base, new subbase or new base is specified, it shall be determined by preliminary laboratory tests at the OWNER'S expense. Optimum lime addition percentage shall be determined by Tex-112-E Admixing Lime to Reduce Plasticity Index of Soils (Atterberg Limits Soil-Lime Series) and/or by ASTM D6276 Test Method for Using pH to Estimate the Soil-Lime Proportion Requirement for Soil Stabilization (pH Soil-Lime Series.) The actual minimum lime dosage to be applied shall be 1% above the minimum test results.

301.2.1.4. Lime Delivery and Storage. If hydrated lime is furnished in bags, each bag shall bear the manufacturer's certified weight. Bags varying more than 5-percent by weight may be rejected, and the average weight of the bags in any shipment, as shown by weighing 50 bags taken at random, shall not be less than the manufacturer's certified weight. If lime is furnished in trucks, each truck shall bear the weight of lime measured on certified scales, or the CONTRACTOR shall place a set of standard platform truck scales or hopper scales at a location approved by the OWNER.

Hydrated lime and quicklime shall be stored and handled in closed, weatherproof containers until immediately before distribution on the road. If storage bins are used, they shall be completely enclosed. Hydrated lime bags shall be stored in weatherproof buildings with adequate protection from ground dampness. Quicklime, when permitted, shall be shipped only in bulk; bagged material shall not be acceptable.

301.2.1.5. Water. Water shall conform to the requirements of Item 303.2.7. Water.

301.2.1.6. Soil. The soil shall consist of the in-situ soil or approved soil, free from vegetation, roots, or other objectionable matter. It may be either the material encountered in the existing section, material secured from approved sources shown on the plans or as designated by the OWNER, or a combination of existing and additional soil from approved sources, as shown on the plans, or as directed by the OWNER.

301.2.1.7. Recycled/Reclaimed Asphalt Pavement. Recycled/Reclaimed asphalt pavement is defined as a salvaged, milled, pulverized, broken or crushed asphaltic pavement uncontaminated by dirt or other objectionable materials.

301.2.1.8. Rejection. Any materials that do not conform to the requirements of this specification shall be rejected.

301.2.2. Equipment. Machinery, tools and equipment necessary for proper performance of the work shall be on the project and approved by the OWNER prior to the beginning of construction operations.

301.2.3. Lime Treatment Construction Methods.

301.2.3.1. General. It is a primary requirement of this specification to secure a completed course of treated material containing a uniform lime mixture, free from loose or segregated areas, or uniform density and moisture content, well bound for its full depth, and with a smooth surface and suitable for placing subsequent courses. It shall be the responsibility of the CONTRACTOR to regulate the sequence of work, to use the specified amount of lime, maintain the work and rework the courses as necessary to meet the above requirements.

Prior to beginning any lime treatment, the roadbed shall be constructed and shaped to conform to the typical sections, lines and grades as shown on the plans or as established by the OWNER.

In cases where groundwater is present, application of lime for stabilization shall be evaluated by the OWNER.

301.2.3.2. Section Held for Future Use.

301.2.3.3. General Construction.

301.2.3.3.1. Treatment for Materials in Place. Materials to be treated shall be excavated to the secondary grade (proposed bottom of lime treatment) and removed or windrowed to expose the secondary grade. Any wet or unstable material below the secondary grade shall be corrected by scarifying, adding lime and compacting until it is of uniform stability. The excavated material shall then be spread to the desired cross section.

If the CONTRACTOR elects to use a cutting or pulverizing machine that shall remove the subgrade material accurately to the secondary grade and to pulverize the material at the same time, CONTRACTOR shall not be required to expose the secondary grade or windrow the material. However, the CONTRACTOR shall be required to roll the subgrade before using the pulverizing machine and correct any soft areas that this rolling may reveal. This method shall be permitted only where a machine is provided which shall insure that the material is cut uniformly to the proper depth and which has cutters that shall place the secondary grade to a smooth surface over the entire width of the cut. The machine shall be of such design that a visible indication is given at all times that the machine is cutting to the proper depth.

301.2.3.3.2. Treatment for New Materials. The base and subbase materials, as provided in the governing specifications, shall be delivered, placed and spread in the required amount per station. The material shall be manipulated as specified and thoroughly mixed prior to the addition of the lime.

301.2.3.4. Lime Application. Lime shall be spread only on that area where the first mixing operation can be completed in the same working day, except that quicklime shall be mixed at the time of application. The application and mixing of lime with the materials shall be accomplished by the methods hereinafter described unless otherwise approved by the OWNER.

301.2.3.4.1. Dry Placing Quicklime. Quicklime may be placed dry if it is in pebble form. A spreader or motor grader shall be used to spread pebble Quicklime.

301.2.3.4.2. Slurry Placing.

Hydrated Lime or Commercial Lime Slurry. Lime shall be mixed with water and applied as a thin water suspension or slurry. Type B, commercial lime slurry, shall be applied with a lime percentage not less than that applicable for the grade used. The distribution of lime at the rate shown on the plans shall be attained by successive passes over a measured surface of roadway until the proper moisture and lime content have been achieved.

Quicklime. When Quicklime is applied as a slurry, the amount of dry quicklime shall be 80-percent of the amount shown on the plans. The residue from the Quicklime slurrying procedure shall be spread uniformly over the length of the roadway currently being processed unless otherwise approved by the OWNER. 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.

301.2.3.5. Mixing. Mixing procedure shall be the same for “dry placing” or “slurry placing” as hereinafter described.

301.2.3.5.1. Treatment for Materials-In-Place. Material and lime shall be thoroughly mixed by approved road mixers or other approved equipment and the mixing continued until a homogeneous, friable mixture of material and lime is obtained, free from all clods or lumps. Materials containing plastic clay or other materials which shall not readily mix with lime shall be mixed as thoroughly as possible at the time of the lime application, brought to the proper moisture content, sealed with a pneumatic roller, and left to cure 1- to 4-days as directed by the OWNER. During the curing period,

the material shall be kept moist. After the required curing 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 raking, blading, discing, harrowing, scarifying or the use of other approved pulverization methods so that when all nonslaking aggregates obtained on the No. 4 sieve are removed, the remainder of the material shall meet the requirements of Table 301.2.3.5.1.(a) Lime Treated Materials-In-Place when tested dry by laboratory sieves.

Table 301.2.3.5.1.(a) Lime Treated Materials-In-Place

Sieve Size	Minimum Passing
1¾-in. (45mm)	100%
No. 4 (4.75mm)	60%

1. Recycled asphalt pavement shall be pulverized so that 100-percent shall pass a 2-in. (50mm) sieve.

During the interval of time between application and mixing, hydrated lime that has been exposed to the open air for a period of 6-hours or more, or to excessive loss due to washing or blowing, shall not be accepted for payment.

In addition to the above, when pebble quicklime is used, the material and lime shall be mixed as thoroughly as possible at the time of application. Sufficient moisture shall be added during the mixing to hydrate the quicklime. After mixing, and prior to compaction, the mixture of material, quicklime and water shall be moist cured for 2- to 7-days, as approved by the OWNER. After curing, mixing shall continue until the pulverization requirements are met.

301.2.3.5.2. Treatment of New Material. The base or subbase material, lime and required water shall be thoroughly mixed and blended by approved road mixers or other approved equipment and the mixing continued until a homogeneous, friable mixture is obtained. When lime is placed as a slurry and mixed by the use of blades, the material shall be bladed as the lime water mixture is applied; after the total amount has been placed, the mixture shall be thoroughly blended to the satisfaction of the OWNER.

During the interval of time between application and mixing, hydrated lime that has been exposed to the open air for a period of 6-hours or more, or to excessive loss due to washing or blowing, shall not be accepted for payment.

301.2.3.6. Compaction. Compaction of the mixture shall begin immediately after final mixing and in no case later than 3-days after final mixing. The material shall be aerated or sprinkled as necessary to provide optimum moisture. Compaction shall begin at the bottom and shall continue until the entire depth of the mixture is uniformly compacted as shown on the plans or specified by the OWNER. The compacted mixture shall have a uniform density of not less than 95-percent of the maximum density as determined by ASTM D698 Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3). Moisture content shall be within minus 2-percent to plus 4-percent of optimum. After each section is completed, such tests as are necessary shall be made by the OWNER. If any portion fails to meet the density specified, it shall be reworked as necessary to obtain the specified density. After the mixture has been compacted, the surface shall be shaped to the required line, grades and cross sections and then rolled sufficiently to prevent hairline cracking.

301.2.3.7. Maintenance. The CONTRACTOR shall be required to maintain the completed soil lime base within the limits of its contract in good condition, satisfactory to the OWNER as to grade, crown and cross section until such time as the surface course is constructed. The surface of the compacted layer shall be kept moist until covered by other base or paving material or application of a curing seal of emulsified asphalt conforming to requirements of Item 302.3.5. Emulsions for Priming, Curing and Erosion Control (PCE). If a curing seal is used, it should be applied as soon as possible after completion of final rolling, at a rate of between 0.10- and 0.20-gallons-per-square-yard, the exact rate to be determined by the OWNER. No equipment or traffic shall be permitted on lime treated material for 72-hours after curing seal is applied, unless otherwise permitted by the OWNER. In cases where subgrade treatment or subbase sets up sufficiently to prevent objectionable damage from traffic, such layers may be opened to traffic 2-

days after compaction. The CONTRACTOR shall immediately repair all irregularities or other defects that may occur at the CONTRACTOR'S expense. Repairs are to be made as directed by the OWNER and in a manner to insure restoration of a uniform surface and durability of the portion repaired.

301.2.4. Measurement and Payment. Lime treatment shall be measured for payment in square-yards for the thickness shown in the plans for the surface area of completed and accepted work. The measurement for lime shall be by the ton of 2000-pounds dry weight. The measured tonnage of (dry) quicklime shall be multiplied by the conversion factor 1.25 to give the equivalent quantity of hydrated lime (dry) which shall be the basis of payment.

Lime treatment shall be paid for at the contract unit price per square-yard, as provided in the proposal and contract. The contract unit price shall be the total compensation for preparing the roadbed; for loosening, pulverizing, application of lime, water content in the slurry mixture and the mixing water; mixing, shaping, sprinkling, compacting, finishing, curing and maintaining; for manipulations required; and for all labor, equipment, fuels, tools and incidentals necessary to complete the work, all in accordance with the plans and specifications.

Lime material measured as provided in the this item shall be paid for at the unit price bid for "lime material" which price shall be full compensation for furnishing the material; for all freight involved; for all unloading, storing and handling; and for all labor, equipment, fuels, tools and incidentals necessary to complete the work.

301.3. PORTLAND CEMENT TREATMENT

This item shall consist of the treatment of the subgrade, subbase or base course which is to be composed of a compacted mixture of soil, and/or pulverized recycled asphalt pavement, Portland cement and water and shall be constructed as herein specified and in conformity to the cross sections, lines and grades as established by the OWNER. In the event new materials are placed, rather than using in-situ soils, the subbase or base shall be constructed as herein specified and in conformity with the items governing the base or subbase courses.

301.3.1. Materials.

301.3.1.1. Portland Cement. Cement shall be ASTM C150 Type I, II or IP and conform to the requirements of Item 303.2.2. Portland Cement.

301.3.1.2. Water. Water shall conform to the requirements of Item 303.2.7. Water.

301.3.1.3. Soil. The soil shall consist of the in-situ soil or approved soil, free from vegetation, roots, or other objectionable matter. It may be either the material encountered in the existing section, material secured from approved sources shown on the plans or as designated by the OWNER, or a combination of existing and additional soil from approved sources, as shown on the plans, or as directed by the OWNER.

301.3.1.4. Recycled/Reclaimed Asphalt Pavement. Recycled/Reclaimed asphalt pavement is defined as a salvaged, milled, pulverized, broken or crushed asphaltic pavement uncontaminated by dirt or other objectionable materials.

301.3.2. Equipment. All equipment necessary to properly prosecute, perform and complete the work within the contract time shall be on the project and shall be approved by the OWNER as to type and condition before the CONTRACTOR shall be permitted to begin construction operations on which the equipment is to be used.

The cement-modified soil layer may be constructed with any machine or combination of machines and auxiliary equipment that shall produce the results meeting the requirements for soil pulverization, cement application, water application, mixing, incorporation of materials, compaction, finishing and curing as specified herein. The CONTRACTOR shall at all times provide sufficient equipment to enable continuous performance of the work and its completion in the required number of working days.

301.3.3. Portland Cement Treatment Construction Methods.

301.3.3.1. General. The primary requirement of this specification is to secure a complete course of treated material containing a uniform Portland cement mixture, free from loose or segregated areas, of uniform density and moisture content, well bound and compacted for its full depth with a smooth surface suitable for placing additional subbase, base or surface courses. It shall be the responsibility of the CONTRACTOR to regulate the sequence of work, to process a sufficient quantity of material so as to

provide full depth as shown on plans, to use the proper amount of Portland cement, maintain the work and to rework the courses as necessary to meet the foregoing requirements.

Cement stabilized base shall not be mixed or placed when the air temperature is below 40°F and falling, but may be mixed or placed with the air temperature is above 35°F and rising, the temperature being taken in the shade and away from artificial heat, and with the further provisions that cement stabilized base shall be mixed or placed only when weather conditions, in the opinion of the OWNER, are suitable.

301.3.3.2. Treatment for Materials-In-Place. Before other construction operations are begun, the roadbed shall be graded and shaped as required to construct the Portland cement treatment for material in place in conformance with the lines, grades, thickness and typical cross sections shown on the plans. Unsuitable soil or material shall be removed and replaced with acceptable soil. The subgrade shall be firm and able to support without displacement the construction equipment and achieve the compaction herein specified. Soft or yielding subgrade shall be corrected and made stable before construction proceeds.

The soil and/or recycled asphalt pavement shall be so pulverized that at the completion of moist-mixing, it meets the gradation in Table 301.3.3.2.(a) Cement Treated Materials-In-Place.

Table 301.3.3.2.(a) Cement Treated Materials-In-Place

Sieve Size	Minimum Passing by Dry Weight[1,2]
1-in. (25mm)	100%
No. 4 (4.75mm)	80%

1. Exclusive of gravel or stone retained on these sieves.
2. Recycled asphalt pavement shall be pulverized so that 100-percent shall pass a 2-in. (50mm) sieve.

301.3.3.2.1. Application of Cement to Materials-In-Place. Portland cement shall be spread by an approved dry or slurry method uniformly on the soil at the rate specified on the plans or as determined by preliminary laboratory tests. If a bulk cement spreader is used, it shall be positioned by string lines or other approved method during spreading to insure a uniform distribution of cement. Cement shall be applied only to such an area that all the operations can be continuous and completed in daylight within 6-hours of such application.

The percentage of moisture in the soil at the time of cement application shall not exceed the quantity that shall permit uniform and intimate mixture of soil and cement during dry-mixing operations, and it shall not exceed the specified optimum moisture content for the soil and cement mixture. In the event of high soil-moisture contents, cement may be applied at one-half the specified rate when approved by the Engineer. The remainder of the application rate of cement shall be applied the following day(s), not to exceed 48-hours. The usual construction sequence shall then be resumed.

No equipment, except that used in the spreading and mixing, shall be allowed to pass over the freshly spread cement until it is mixed with the soil.

301.3.3.2.2. Mixing and Processing of Stabilized Materials-In-Place. Any method used to achieve the specified results is acceptable. Mixing shall continue until a homogeneous, friable mixture of the material and cement is obtained, free from all clods or lumps. The mixture shall be kept within moisture tolerances throughout the operation.

301.3.3.2.3. Compaction and Finishing of Stabilized Materials-In-Place. Compaction shall begin after mixing and after gradation and moisture requirements have been met. The material shall be compacted to at least 95-percent of the maximum density as determined by ASTM D698 Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft3). At the start of compaction, the percentage of moisture in the mixture and in unpulverized soil lumps, based on oven-dry weights, shall be within 2-percentage-points of the specified optimum moisture content and shall be less than the quantity which shall cause the soil-cement mixture to become unstable during compaction and finishing. When the uncompacted soil-cement mixture is wetted by rain so that the

average moisture content exceeds the tolerance given at the time of final compaction, the entire section shall be reconstructed in accordance with this specification at the sole expense of the CONTRACTOR. The specified optimum moisture content and density shall be determined in the field on the representative samples of soil-cement mixture obtained from the area being processed. Final moisture content shall be within minus-2- to plus-4-of-optimum.

Prior to the beginning of compaction, the mixture shall be in a loose condition for its full depth. Compaction shall begin at the bottom and shall continue until the entire depth of the mixture is uniformly compacted. The loose mixture shall then be uniformly compacted to the specified density within 2-hours. After the soil and cement mixture, except the top mulch, is compacted, water shall be uniformly applied as needed and thoroughly mixed in. The surface shall then be reshaped to the required lines, grades and cross section and then lightly scarified to loosen any imprint left by the compacting or shaping equipment.

The resulting surface shall be thoroughly rolled with a pneumatic tire roller and "clipped," "skinned," and "tight-bladed" by a power grader to a depth of approximately ¼-in., moving all loosened soil and cement from the section. The surface shall then be thoroughly compacted with the pneumatic roller, adding small increments of moisture as needed during rolling. When directed by the OWNER, surface finishing methods may be varied from this procedure, provided a dense, uniform surface, free of surface material, is maintained at its specified optimum during all finishing operations. Surface compaction and finishing shall proceed in such a manner as to produce, in not more than 2-hours, a smooth, closely knit surface, free of cracks, ridges or loose material, conforming to the drawn grade and line shown on the plans.

OWNER shall conduct in-place density tests shall as outlined in ASTM D2922 Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth). In-place density tests shall be performed at the rate of one-per-300-linear-ft. of paving for two (2) lanes. The suitability of the modification shall be confirmed by Atterberg Limit testing at the rate of one-test-per-2,500-cubic-yards of processed material.

In addition to the requirements specified for density, the full depth of the material shown on the plans shall be compacted to the extent necessary to remain firm and stable under construction equipment. After each section is completed, tests as necessary will be made by the OWNER. If the material fails to meet the density requirements, it shall be reworked as necessary to meet these requirements. 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 section shown on the plans and to the established lines and grades. Should the material, due to any reason or cause, lose the stability, density and finish before the next course is placed or the work is accepted, it shall be recompacted and refinished at the sole expense of the CONTRACTOR.

301.3.3.3. Plant-Mixed Cement Treated Base.

301.3.3.3.1. Subgrade Preparation. Before other construction operations are begun, the area to be paved shall be graded and shaped as required to receive the cement treated base in conformance with the grades, lines, thicknesses and typical cross-section shown on the plans. Unsuitable subgrade soil or material shall be removed and replaced with acceptable soil. The subgrade shall be firm and able to support without displacement of the construction equipment and compaction. Soft or yielding subgrade shall be corrected and made stable before construction proceeds.

301.3.3.3.2. Mixing and Processing for Plant-Mixed Cement Treated Base. The aggregate, cement and water shall be mixed in a pug mill as approved by the Engineer. The plant shall be equipped with feeding and metering devices that add the aggregate, cement and water into the mixer in the specified quantities to produce a mixture that meets or exceeds the mix design criteria. Aggregate and cement shall be mixed sufficiently to prevent cement balls from forming when the mix water is added. Mixing time shall be sufficient to assure an intimate, uniform mixture of aggregate, cement and water. The percentage of moisture in the aggregate, at the time of cement application shall be the amount that assures a uniform and intimate mixture of aggregate and cement during

mixing operations. It shall not exceed the specified moisture content required for adequate compaction.

Free access to the plant shall be provided to the OWNER for construction quality control. The mixture shall be hauled to the paving area in trucks having beds cleaned of deleterious material.

The CONTRACTOR shall submit a mix design for the proposed Cement Treated Base (CTB) to the OWNER for approval in advance of the proposed work. Unconfined compression strength test results shall be submitted with the mix design by the supplier of the CTB material. Work shall not begin until the mix design is approved by the OWNER.

301.3.3.3.3. Placement of Plant-Mixed Cement Treated Base. The mixture shall be placed on a moistened subgrade in a uniform layer by any approved method of spreading that will deposit the required quantity per lineal foot, without segregation, to produce a uniformly compacted base conforming to the grade and cross-section. Not more than 30-minutes shall elapse between placement of cement treated base in adjacent lanes at any location except at longitudinal and transverse construction joints. Compaction shall start as soon as possible after spreading. Elapsed time between the addition of water to the cement treated base mixture and the start of compaction shall not exceed 60-minutes under normal conditions. The Engineer may alter this time if environmental conditions, such as temperature, humidity or wind conditions would justify such a change. Laboratory tests may be required to verify changes in compaction time limits.

301.3.3.3.4. Compaction and Finishing of Plant-Mixed Cement Treated Base. At the start of compaction, the percentage of moisture in the mixture shall not be more than one-percentage-point-below or two-percentage-points-above the specified optimum moisture content, and shall be less than that quantity which will cause the cement treated base mixture to become unstable during compaction and finishing. The specified optimum moisture content and density shall be determined in the field by a Moisture-Density Test AASHTO T134 or ASTM D558 Test Methods for Moisture-Density Relations of Soil-Cement Mixtures, on representative samples of cement treated base mixture obtained from the area prior to compaction. Prior to compaction, the mixture shall be in a loose condition for its full depth. The loose mixture shall then be compacted uniformly to the specified density. During compaction operations, initial shaping may be required to obtain uniform compaction and required grade and cross-section.

When initial compaction is completed, the surface of the cement treated base shall be shaped to the required lines, grades and cross-section. The moisture content of the surface material shall be maintained at not less than its specified optimum moisture content during finishing operations. If any reshaping of the surface is necessary, it shall be lightly scarified to remove any compaction planes, scales or smooth surfaces left by equipment. Final compaction shall then be continued until uniform and adequate density is obtained. Cement treated base shall be uniformly compacted to a minimum of 95-percent of maximum density. Compaction and finishing shall be done in such a manner as to produce, in not longer than two-hours, a smooth, dense surface free of compaction planes, cracks, ridges, or loose material.

301.3.3.4. Finishing and Preparation for Surfacing. After the final layer or course of the cement-modified soil 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 as directed with a pneumatic tire or other suitable roller sufficiently light to prevent hair cracking. Preparation for final surfacing may begin immediately.

301.3.3.5. Protection and Cover. After the roadway has been finished as specified herein, it shall be immediately protected against rapid drying by applying a curing seal of emulsified asphalt at the rate of 0.2-gallon-per-square-yard. The curing seal shall consist of emulsified asphalt conforming to requirements of Item 302.3.5. Emulsions for Priming, Curing and Erosion Control (PCE). Immediately prior to application of the curing seal, the section shall be wetted by the use of pressure water distributors so that all voids in the soil-cement surface are filled with water, but without free water standing on the surface. The curing seal shall be applied while this moisture condition exists so that

undue asphalt penetration of the soil-cement surface shall be prevented; and at the same time aided in complete coverage by the curing seal.

Should it be necessary for construction equipment or other traffic vehicles to pass over the section before the curing seal has dried sufficiently to prevent pickup, if shall be the responsibility of the CONTRACTOR to dust or sand the surface before such use. The CONTRACTOR shall also maintain the curing cover for 7-days so that all of the soil-cement base course shall be covered effectively with curing seal during this period. The curing seal shall remain in place for the additional asphalt-wearing surface.

301.3.3.6. Opening to Traffic. The CONTRACTOR shall not be permitted to drive heavy equipment over completed portions. Pneumatic-tired equipment required for hauling cement and water may be permitted to drive over after the surface has hardened sufficiently to prevent the equipment from marring the surface, provided that protection and cover are not impaired. The soil-cement course may be opened to local traffic as soon as the curing seal has been applied and dusted or sanded as necessary to prevent it from being picked up by traffic. Completed portions may be opened to all traffic after 7-days or as directed by OWNER.

301.3.3.7. Maintenance. The CONTRACTOR shall be required within the limits of its contract to maintain the soil-cement treatment in good condition from the time it first starts work until all work shall have been completed. Maintenance shall include immediate repairs of any defect that may occur after the cement is applied. Such maintenance work shall be done by the CONTRACTOR at the CONTRACTOR'S expense and repeated as often as necessary to keep the area continuously intact. Repairs are to be made in such a manner as to insure restoration of a uniform surface for the full depth of treatment. Any low area of treated subgrade shall be remedied by scarifying the surface to a depth of at least 2-in., filling the area with treated material and compacting. Any low area of subbase or base shall be remedied by replacing the material for the full depth of subbase or base treatment rather than adding a thin layer of stabilized material to the completed work.

301.3.4. Measurement and Payment. Portland cement treatment shall be measured by the square-yard of completed and accepted cement treated course. Measurement for cement shall be by the ton of 2000-pounds of dry weight, as determined by certified weight tickets. No allowance shall be made for any materials used or work done outside the limits as established by the OWNER.

The work performed and material furnished as prescribed by this item and measured as provided in this item shall be paid for at the unit price bid for soil-cement treated subgrade, subbase, or base course, which price shall be full compensation for pulverizing or providing the soil material; handling, hauling and spreading dry or slurry cement, mixing the cement with the soil either in-place or in a mixing plant; furnishing, hauling and mixing water with the soil-cement mixture; spreading and shaping the mixture; compacting the mixture, including all rolling required for this compaction; surface finishing; curing; and for all manipulation, labor, equipment, appliances, tools and incidentals necessary to complete the work and carry out the maintenance provisions in this specification.Cement material measured as provided in this item shall be paid for at the unit price bid for cement material, which price shall be compensation for furnishing the material, for all freight involved, for all unloading and storing, and for all labor, equipment, fuels, tools and incidentals necessary to complete the work, all in accordance with the plans and these specifications.

301.4. ASPHALT EMULSION TREATMENT

This item shall consist of treating subgrade, subbase, and base courses by the pulverization, addition of asphalt base stabilization agent, mixing and compacting the mixed material to the required density. This item applies to natural ground, embankment, base or subbase courses placed under this contract, which shall be constructed as specified herein and in conformity with the typical section, lines and grades as shown on the plans.

Asphalt stabilization of recycled material such as crushed concrete or other non-hazardous recycled materials, processed recycled asphalt pavements, bottom ash, foundry slag, glass, recycled crumb rubber to create subgrade, subbase or base courses shall conform to TxDOT Special Specification 3157 Cold Processed - Recycled Paving Material (RPM) for Use as Aggregate Base Course. Asphalt emulsion for such recycling shall conform to Item 302.3.6. Specialty Emulsions or Item 302.3.7. Emulsion for In-Place Asphalt Recycling, as specified by the OWNER.

301.4.1. Materials.

301.4.1.1. Asphalt Soil (Base) Stabilization Agent. The product shall be composed of petroleum of resin oil base with selective hardening and drying agents to form a stable subgrade, subbase, or base. Independent laboratory tests shall certify compliance with requirements of Table 301.4.1.1.(a) Asphalt Soil Stabilization Agent Requirements, as specified on the plans.

If the minimum design strength or percent asphalt base stabilization agent to be used for the treated subgrade, existing base, new subbase or new base is specified, it shall be determined by preliminary laboratory tests at the OWNER'S expense.

Table 301.4.1.1.(a) Asphalt Soil Stabilization Agent Requirements

Property	Test Method, Test Parameters	Required Value	
		Minimum	Maximum
Appearance	Visual Inspection	Brown Liquid	
Viscosity S.F. at 77°F Sec	ASTM D244 Emulsified Asphalts	5	175
Residue, % min	ASTM D244, modified[1]	55	65
Penetration 77°F, Sec		5	40
Miscibility Test	ASTM D244, modified[2]	No coagulation	
Moisture, wt %		-	45
Volatile %		25	-
% Non-Volatile Soluble in Trichloroethylene	AASHTO T 45-56	-	8
Accelerated Weathering (2-year exposure)	Federal Spec TT C-555 B, 40 ml	No material deterioration after exposure	
Resistance To wind and Driven Rain (@ 98 mph)	Federal Spec TT C-555 B, As 4ml sealer after cure	Passes/no wt. gain	
Ash, % wt.		-	8
Polymer, % wt.		-	4
Particle Charge	ASTM D244	Positive	
Flash Point	TCC	275°F	
Shaker Test 2- to 4-hrs.	Mix Burrell Wrist Action Shaker Model 75 set on Level 7, diluted 1 part water to 4 parts soil stabilizer, Sieve #40	-	1%

1. ASTM D244 Modified Evaporation Test for percent of residue is made by heating 50-gram sample to 300°F until foaming ceases, then cool immediately and calculate results.

2. Test procedure identical with ASTM D244, except that 0.02 Normal Calcium Chloride solution shall be used in place of distilled water.

301.4.1.2. Base and Subbase Materials. Base and subbase materials shall meet the requirements shown on the plans or in the pertinent specifications.

301.4.1.3. Delivery and Storage. If asphalt base stabilization agent is furnished in trucks, each truck shall bear the weight of asphalt base stabilization agent measured on certified scales, or the CONTRACTOR shall place a set of standard platform truck scales or hopper scales at a location approved by the OWNER.

Asphalt base stabilization agent shall be stored and handled in tank, tanker or distributor truck until immediately before distribution on the road. Asphalt base stabilization agent shall be stored in freeze-proof containers.

301.4.2. Equipment. Machinery, tools and equipment necessary for proper performance of the work shall be on the project and approved by the OWNER prior to the beginning of construction operations. All machinery, tools and equipment used shall be maintained in a satisfactory and workmanlike manner.

301.4.3. Asphalt Emulsion Treatment Construction Methods.

301.4.3.1. General. It is a primary requirement of this specification to secure a completed course of treated material containing a uniform asphalt base stabilization agent mixture, free from loose or segregated areas, of uniform density and moisture content, well bound for its full depth, and with a smooth surface and suitable for placing subsequent courses. It shall be the responsibility of the CONTRACTOR to regulate the sequence of work, to use the proper amount of asphalt base stabilization agent, maintain the work and rework the courses as necessary to meet the above requirements.

Prior to beginning any asphalt base stabilization agent treatments, the roadbed shall be constructed and shaped to conform to the typical sections, lines and grades as shown on the plans or as established by the OWNER.

301.4.3.2. General Construction.

301.4.3.2.1. Treatment for Materials-In-Place. Materials to be treated shall be excavated to the secondary grade (proposed bottom of asphalt base stabilization agent) and removed or windrowed to expose the secondary grade. Any wet or unstable material below the secondary grade shall be corrected by scarifying, adding asphalt base stabilization agent and compacting until it is of uniform stability. The excavated material shall then be spread to the desired cross section.

If the CONTRACTOR elects to use a cutting or pulverizing machine that shall remove the subgrade material accurately to the secondary grade and to pulverize the material at the same time, CONTRACTOR shall not be required to expose the secondary grade or windrow the material. However, the CONTRACTOR shall be required to roll the subgrade before using the pulverizing machine and correct any soft areas that this rolling may reveal. This method shall be permitted only where a machine is provided which shall insure that the material is cut uniformly to the proper depth and which has cutters that shall place the secondary grade to a smooth surface over the entire width of the cut. The machine shall be of such design that a visible indication is given at all times that the machine is cutting to the proper depth.

301.4.3.2.2. Treatment for New Materials. The base and subbase material, as provided in the governing specifications, shall be delivered, placed and spread in the required amount per station. The material shall be manipulated as specified and thoroughly mixed prior to the addition of the asphalt base stabilization agent.

301.4.3.3. Asphalt Base Stabilization Agent Application. Asphalt base stabilization agent shall be spread only on that area where the mixing can be completed in the same working day. Asphalt base stabilization agent shall be mixed with water and applied as a thin water suspension. The distribution of asphalt stabilization agent at the rate shown on the plans shall be attained by successive passes over a measured surface of roadway until the proper moisture content and asphalt base stabilization agent content has been achieved.

The asphalt base stabilization agent shall be distributed at a uniform rate and in such a manner as to reduce heavy or light areas to a minimum. A motor grade can be used to cover the exposed asphalt base stabilization agent. If necessary, the material shall be sprinkled until a proper moisture content has been achieved.

301.4.3.4. Mixing. The application and mixing of asphalt base stabilization agent with the material shall be thorough. During the interval of time between application and mixing, asphalt base stabilization agent that has been exposed to the open air for a maximum time of 2-hours, or a shorter period when the breaking of the emulsion has occurred, shall not be accepted for payment. (*Breaking of the emulsion is when the emulsion is over exposed on the surface without mixing, thus turning it from a brown color to black. The color change is due to the evaporation of the water from the emulsion, thus rendering it ineffective in mixing in the soil, base or subbase material*). The CONTRACTOR is responsible for monitoring the application and the mix time of the asphalt stabilization agent with the soil, base or subbase material. The overexposed area shall be retreated with another application of asphalt base stabilization agent and mixed.

301.4.3.4.1. Treatment for Materials-In-Place. Material and asphalt base stabilization agent shall be thoroughly mixed by approved road mixers or other approved equipment and the mixing

continued until a homogeneous, friable mixture of material and asphalt base stabilization agent is obtained, free from all clods or lumps. Materials containing plastic clay or other materials which shall not readily mix with asphalt base stabilization agent shall be mixed as thoroughly as possible, and meet the requirements of Table 301.4.3.4.1.(a) Asphalt Emulsion Treated Materials-In-Place when tested dry by laboratory sieve at the time of the asphalt base stabilization agent application, brought to the proper moisture content, sealed with a pneumatic roller, and left to cure 1 to 2 days as directed by the OWNER. During the curing period, the material shall be kept moist.

Table 301.4.3.4.1.(a) Asphalt Emulsion Treated Materials-In-Place

Sieve Size	Minimum Passing by Dry Weight[1,2]
1¾-in. (45mm)	100%
No. 4 (4.75mm)	60%

301.4.3.4.2. Treatment of New Material. The base or subbase material, asphalt base stabilization agent and required water shall be thoroughly mixed and blended by approved road mixers or other approved equipment and the mixing continued until a homogeneous, friable mixture is obtained. When the asphalt base stabilization agent is placed and mixed by the use of blades, the material shall be bladed as the asphalt base stabilization agent water mixture is applied; after the total amount has been placed, the mixture shall be thoroughly blended to the satisfaction of the OWNER.

301.4.3.4.3. Central Mixing Plant. The soil, asphalt base stabilization agent and water shall be mixed in a pugmill either of the batch or continuous-flow type. The plant shall be equipped with feeding and metering devices which shall add the soil, asphalt base stabilization agent and water into the mixer in the specified quantities. Soil and asphalt base stabilization agent shall be mixed sufficiently to prevent asphalt base stabilization agent balls from forming when water is added. Mixing shall continue until a uniform and intimate mixture of soil, asphalt base stabilization agent and water is obtained. The mixture shall be placed on the moistened subgrade in a uniform layer by an approved spreader or spreaders.

After mixing asphalt stabilization agent with the base or subbase material the following conditions shall be met:

(1) Not more than 3-hours shall elapse between the placement of soil-asphalt emulsion mixture in adjacent lanes and placement at any location except at longitudinal construction joints.
(2) Not more than 3-hours shall elapse between the start of spreading the soil-asphalt emulsion mixture and start of compaction.
(3) Not more than 4-hours shall elapse between the start of mixing and the start of compaction.

The layer of soil-asphalt base stabilization agent shall be uniform in thickness and surface contour, and in such quantity that the completed base shall conform to the required grade and cross section. Dumping of the mixture in piles or windrows upon the subgrade shall be permitted.

301.4.3.5. Compaction. Compaction of the mixture shall begin immediately after final mixing and in no case later than 2-days after final mixing. The material shall be aerated or sprinkled as necessary to provide optimum moisture content. At the start of compaction, the moisture in the mixture and in unpulverized soil lumps, based on oven-dry weights, shall be within minus-2- to plus-2-percent-of-optimum. The specified optimum moisture content and density shall be determined in the field on the representative samples of soil-asphalt base stabilization agent mixture obtained from the area being processed. Prior to the beginning of compaction, the mixture shall be in a loose condition for its full depth. The loose mixture shall be uniformly compacted to the specified density within 4-hours. Compaction shall begin at the bottom and shall continue until the entire depth of the mixture is uniformly compacted as shown on the plans or specified by the OWNER.

The compacted mixture shall have a uniform density of not less than 95-percent of the maximum density as determined by ASTM D698 Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3). Final moisture content shall be within minus-2- to plus-4-percent-of-optimum. If the soil-asphalt base stabilization agent mixture is wetted by rain so that the average moisture content

exceeds the tolerance given at the time of final compaction, the entire section shall be reconstructed in accordance with this specification at the sole expense of the CONTRACTOR. After the soil and asphalt base stabilization agent mixture, except the top layer, is compacted, water shall be uniformly applied as needed and thoroughly mixed in with a spike tooth harrow or equal. The surface shall then be reshaped to the required lines, grades and cross sections and then lightly scarified to loosen any imprint left by the compacting or shaping equipment. After each section is completed, such tests as are necessary shall be made by the OWNER. If any portion fails to meet the density specified, it shall be reworked as necessary to obtain the specified density at the sole expense of the CONTRACTOR.

301.4.3.6. Finishing, Curing and Preparation for Surfacing. The resulting surface shall be thoroughly rolled with a pneumatic tire roller and "clipped", "skinned", and "tight-bladed" by a power grader to a depth of approximately ¼-in., moving all loosened soil and asphalt base stabilization agent from the section. The surface shall then be thoroughly compacted with the pneumatic roller, adding small increments of moisture as needed during rolling. When directed by the OWNER, surface finishing methods maybe varied from this procedure, provided a dense, uniform surface, free of surface material, is maintained at its specified optimum during all finishing operations. Surface compaction and finishing shall proceed in such a manner as to produce, in not more than 4-hours, a smooth, closely knit surface, free of cracks, ridges or loose material, conforming to the drawn grade and line shown on the plans.

The completed section shall then be moist-cured for a minimum of 2-days before further courses are added, unless otherwise directed by the OWNER. In cases where, in the opinion of the OWNER, subgrade treatment or subbase sets up sufficiently to prevent objectionable damage from traffic, such layers may be opened to traffic after compaction. The surface of the compacted layer shall be kept moist until covered by other base or paving material or application of a curing seal of emulsified asphalt. If a curing seal is used, it shall be applied as soon as possible after completion of final rolling, at a rate of between 0.10- and 0.20-gallons-per-square-yard, the exact rate to be determined by the OWNER. No equipment or traffic shall be permitted on asphalt base stabilization agent treated material for 12-hours after curing seal is applied, unless otherwise permitted by the OWNER.

301.4.3.7. Maintenance. The CONTRACTOR shall be required to maintain the completed asphalt stabilized base within the limits of its contract in good condition, satisfactory to the OWNER as to grade, crown and cross section until such time as the surface course is constructed. The CONTRACTOR shall immediately repair all irregularities or other defects that may occur at the CONTRACTOR'S expense. Repairs are to be made as directed by the OWNER and in a manner to insure restoration of a uniform surface and durability of the portion repaired.

301.4.4. Measurement and Payment. Asphalt base stabilization agent treatment shall be measured for payment in square-yards for the thickness shown in the plans for the surface area of completed and accepted work. The measurement for asphalt base stabilization agent shall be by the gallon.

Asphalt base stabilization agent treatment shall be paid for at the contract unit price per square yard, as provided in the proposal and contract. The contract unit price shall be the total compensation for preparing the roadbed; for loosening, pulverizing, application of asphalt base stabilization agent, water content in the asphalt base stabilization agent mixture and the mixing water; mixing, shaping, sprinkling, compacting, finishing, curing and maintaining; for manipulations required; and for all labor, equipment, fuels, tools and incidental necessary to complete the work, all in accordance with the plans and specifications. Asphalt base stabilization agent material measured as provided in this item shall be paid for a the unit price bid for "asphalt emulsion base stabilizer" which price shall be full compensation for furnishing the material; for all freight involved; for all unloading, storing and handling; and for all labor, equipment, fuels, tools and incidentals necessary to complete the work.

301.5. FLEXIBLE SUBBASE OR BASE (CRUSHED STONE/CONCRETE)

This item shall consist of a foundation course for a surface course or for other subbase or base courses; shall be constructed as herein specified in one or more courses in conformity with the typical section shown on the plans and to the lines and grades as established by the OWNER.

301.5.1. Material.

301.5.1.1. General. Should the CONTRACTOR elect to produce the material from local pits, the material shall be secured from sources approved by the OWNER. The pits as utilized shall be opened up in such a manner as to immediately expose the vertical faces of all the strata of acceptable material in the depth mined. Unless otherwise directed, the material shall be secured in successive vertical cuts extending through all of the exposed strata, in order that a uniform mixed material shall be secured. Should OWNER allow crushed concrete, materials shall meet the requirements in Table 301.5.1.2.(a) Flexible Base or Subbase Material Requirements, according to specified grade. Additionally, this material shall be free of thin, laminated, or elongated pieces, reinforcing steel, or an excess of shale, dirt, organic matter or other objectionable materials as determined by the OWNER that could be harmful to the production of a homogenous base coarse.

301.5.1.2. Tests and Physical Requirements. Tests shall be performed in accordance with ASTM D4318 Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils. The preparation of samples for testing according to ASTM D4318 shall be in accordance with the requirements of ASTM D2217 Practice for Wet Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants. The material shall also be tested under TxDOT Test Method Tex-116-E The Wet Ball for Determining the Disintegration of Flexible Base Materials. When a magnesium soundness value is shown on the plans the material shall be tested in accordance with Test Method Tex-411-A Soundness of Aggregate Using Sodium Sulfate or Magnesium Sulfate. Physical properties shall meet the requirements in Table 301.5.1.2.(a) Flexible Base or Subbase Material Requirements, according to specified grade.

Table 301.5.1.2.(a) Flexible Base or Subbase Material Requirements

Property	Grade 1		Grade 2	
Triaxial Class	1		1 to 2.3	
Minimum Compressive Strength at lateral pressure 0-psi at lateral pressure 15-psi	 45-psi 175-psi		 35-psi 175-psi	
Master Grading	Sieve	Percent Retained	Sieve	Percent Retained
	1¾” ⅞" ⅜" No. 4 No. 40	0 10-35 30-50 45-65 70-85	2½" 1¾" No. 4 No. 40	0 0-10 45-75 60-85
Maximum Liquid Limit	35		40	
Maximum Plasticity Index	10		12	
Maximum Wet Ball Mill[1]	40		45	
Maximum increase in passing No. 40	20%		20%	
Maximum foreign material allowed	1%		1%	

1. When lightweight aggregates are used, the wet ball mill requirements shall not apply; lightweight aggregate shall meet the Los Angeles Abrasion, Pressure Slaking and Freeze Thaw requirements of TxDOT Item 303 Aggregate for Surface Treatment (Lightweight).

301.5.1.3. Rejection. Aggregate that fails to meet the requirements of these specifications may be rejected by the OWNER. Such rejection shall incur no cost to the OWNER. Aggregate sources from which materials are delivered with properties not meeting these specifications may be rejected as further supply sources to the project by the OWNER.

301.5.2. Construction Methods.

301.5.2.1. Preparation of Subgrade. Preparation of the subgrade shall be in conformity with the requirements of Item 301.3.3.3.1. Subgrade Preparation.

301.5.2.2. Placing. Immediately before placing the subbase or base course material, the subgrade shall be checked as to conformity with grade and section.

The material shall be delivered in approved vehicles of a uniform capacity. It shall be the charge of the CONTRACTOR that the required amount of specified material shall be delivered to secure the proper thickness of the completed subbase or base course. Material deposited on the subgrade shall be spread and shaped the same day. All material shall be moved at least once from the original position in which it is deposited. In the event of inclement weather or other unforeseen circumstances which render impracticable the spreading of the material during the first 24-hour period, the material shall be scarified and spread as directed by the OWNER. The material shall be sprinkled, if directed, and shall then be bladed, dragged and shaped to conform to the typical section as shown on the plans.

All areas and "nests" of segregated coarse or fine material shall be corrected or removed and replaced with well-graded material as directed by the OWNER. If additional binder is considered desirable or necessary after the material is spread and shaped, it shall be furnished and fully incorporated with the material in place by scarifying, harrowing, brooming or by other approved methods. The course shall be sprinkled as required and compacted to the extent necessary to provide not less than the percent density as specified in Item 301.5.2.3. Density. In addition to the requirements specified for density, the full depth of flexible subbase or base shown on the plans shall be compacted to the extent necessary to remain firm and stable under construction equipment. After each course is completed, tests as necessary shall be made by the OWNER unless otherwise specified in the special provisions or in the plans. If the material fails to meet the density requirements, it shall be reworked as necessary to meet these requirements.

Throughout the entire operation, the shape of the course shall be maintained by blading. The surface, upon completion, shall be smooth and in conformity with the typical sections shown on the plans to the established lines and grades. On the surface on which pavement is to be placed, any deviation in excess of ½-in. in cross section in a length of 16-ft. measured longitudinally shall be corrected by loosening, adding or removing material, reshaping and recompacting by sprinkling and rolling. All fractures, settlement, or segregation that develops shall be corrected immediately by scarifying the areas affected, adding suitable material as required, reshaping and recompacting by sprinkling and rolling.

Should the subbase or base course, due to any reason or cause, lose the required stability, density and finish before the surfacing is complete, it shall be recompacted and refinished at the sole expense of the CONTRACTOR.

301.5.2.3. Density. The density required under this item shall not be less than 92-percent compaction as determined by ASTM D1557, Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3). Moisture content shall be within minus-2- to plus-4-of-optimum.

301.5.2.4. Courses. Non full depth asphalt pavements, paving types with flexible base under the curb and gutter, shall be placed and compacted at the same time and in the same operation as the flexible base under the pavement. Where the subbase or base course exceeds 6-in. in thickness, it shall be constructed in two or more courses of equal thickness as indicated on the typical section. A minimum course depth of 3-in. is recommended. The first course shall be placed and compacted under the curb and gutter and under the pavement. The curb and gutter shall then be built upon the first course. The final course of the flexible base shall be placed following the curing time as specified in Item 305.1. Concrete Curb and Gutter.

301.5.3. Measurement and Payment. Work and accepted materials as specified for this item shall be measured by the square-yard of the required depth from plans and specifications completed flexible base as follows:

(1) Where no curb and gutter is in place or is to be constructed in connection with the flexible base, measurement shall be made to the lines shown on the plans or established as the edge of the base to be constructed.

(2) Where curb and gutter is in place or is proposed to be constructed in connection with the placing of the flexible base, measurement shall be made to the lip of the gutter. Material placed under the curb and gutter or behind the curb shall not be measured as flexible base but shall be considered as foundation courses for the curb and gutter.

The work performed and material placed (including additional binder if required) as prescribed for this item, measured as provided in this item, shall be paid for at the unit price bid per square-yard for flexible base, which price shall be full compensation for preparation of subgrade, furnishing of material, hauling, blading, sprinkling, compacting and furnishing all of labor and equipment necessary to complete the work.

301.6. GEOTEXTILES USED IN PAVING APPLICATIONS

301.6.1. Materials.

301.6.1.1. Physical Properties. The fabric properties shall conform to those shown in Table 301.6.1.(a) Geotextiles for Paving, as determined by the Federal Highway Administration Task Force 25 Guidelines using ASTM Test Methods, except where noted.

301.6.1.2. Certification. The manufacturer, if required by the OWNER, shall provide documents stating the name and manufacturer, the chemical composition of the filaments or yarns and test values of the properties of the geotextile. The manufacturer must certify that the material meets or exceeds these specifications.

301.6.1.3. Rejection. Geotextile may be rejected for failure to meet any of the requirements of this specification.

Table 301.6.1.(a) Geotextiles for Paving

Designation (Test Method)	Characteristic	Average Roll Minimum Value
ASTM D4632 Grab Breaking Load and Elongation of Geotextiles	Grab Strength	80-lbs. @ 12-in.-per-minute
ASTM D4632	Elongation @ Break	50% @ 12-in.-per-minute
Tex-616-J, Construction Fabrics	Asphalt Retention	0.5-oz.-per-sq.-ft.
ASTM D276 Identification of Fibers in Textiles	Melting Point	300°F

301.6.2. Construction Methods. Construction methods for each type unit shall be provided by the manufacturer and approved by the OWNER based on the site-specific use.

301.6.3. Measurement and Payment. If provided as a separate contract item, geotextile shall be measured by the square-yard, complete in place.

Geotextile, when provided as a separate pay item, shall be paid for by the square-yard, complete in place, which price shall include materials, hauling, placing, anchoring, and all other work necessary to achieve a functional geotextile layer(s) in the subbase or base layer. If not provided as a separate contract item, geotextile shall be considered subsidiary to those items provided for subbase or base preparation.

ITEM 302. ASPHALT PAVEMENT

302.1. DESCRIPTION

This Item establishes the requirements for asphalt construction. This Item includes material requirements and construction methods for emulsified asphalts, hot-mix asphalt pavement, performance graded (PG) asphalts and other miscellaneous asphaltic materials and polymer additives. Alternately, the use of warm-mix asphalt may be permitted with the OWNER'S approval in accordance with the Texas Department of Transportation Pavement Design Guide - Section 5: Hot-Mix Asphalt Concrete Pavement Mixtures.

302.2. AGGREGATES FOR HOT-MIX ASPHALT PAVEMENT

302.2.1. General Requirements. Aggregates shall conform to the requirements contained in this Item 302.2. Aggregates for Hot-Mix Asphalt Pavement and shall be approved by the OWNER prior to use. The integrity of the aggregate shall be such as to produce a workable material within the limits contained in this specification.

302.2.1.1. Deleterious Substances. Aggregates shall be free from loam, clay balls or other injurious foreign matter occurring either free or as a coating on the aggregates.

302.2.1.2. Storage. Prior to stockpiling of aggregates, the area shall be cleaned of trash, weeds and grass and be relatively smooth. Aggregates shall be stockpiled in such a manner as to prevent mixing of one aggregate with another. Coarse aggregates shall be separated into stockpiles of different gradation, such as a large coarse aggregate and a small coarse aggregate stockpile and such that the grading requirements of the specified type shall be met when the piles are combined in the asphaltic mixture. No coarse aggregate stockpile shall contain more than 15-percent by weight of material that shall pass a No. 10 (2.0mm) sieve except as noted on the plans. Fine aggregate stockpiles may contain coarse aggregate in the amount of up to 20-percent by weight; however, the coarse aggregate shall meet the quality tests specified in Item 302.2.2. Coarse Aggregates. Suitable equipment of acceptable size shall be furnished by the CONTRACTOR to work the stockpiles and prevent segregation of the aggregates.

302.2.1.3. Quality and Testing Requirements. Test of aggregates, when required, shall be made in accordance with applicable Texas Department of Transportation tests or ASTM Test Methods, as shown in the tables below or as required by OWNER.

Requirements for hot-mix asphalt pavement aggregates are shown in Table 302.2.2.(a) Coarse Aggregate Quality Requirements.

302.2.1.4. Aggregate Rejection. Aggregates that fail to meet the requirements of these specifications may be rejected by the OWNER. Such rejection shall incur no cost to the OWNER. The OWNER may reject sources from which materials are delivered with properties not meeting these specifications. Such rejection shall incur no cost to the OWNER.

302.2.2. Coarse Aggregates. Coarse aggregates shall be that portion of the total aggregates retained on the No. 10 sieve (2.0mm). Coarse aggregates shall consist of clean, tough, durable fragments of crushed stone, crushed gravel, or steel slag as specified herein, of uniform quality throughout.

All coarse aggregates shall meet the requirements listed in Table 302.2.2.(a) Coarse Aggregate Quality Requirements.

Table 302.2.2.(a) Coarse Aggregate Quality Requirements[1]

Characteristic	Test Method	Value
Deleterious Material	Tex-217-F, Part I, Determining Deleterious Material in Coarse Aggregates (Bituminous Mixtures)	1.5% Max.
Decantation	Tex-217-F, Part II, Decantation Test for Coarse Aggregate (Bituminous Mixtures)	1.5% Max.
Los Angeles Abrasion	Tex-410-A, Abrasion of Coarse Aggregate Using the Los Angeles Machine (ASTM C131)	35% Max.
Magnesium Sulfate Soundness Loss, 5 Cycle	Tex-411-A, Soundness of Aggregate Using Sodium Sulfate or Magnesium Sulfate	30% Max. (lower value may be shown on plans)
Coarse Aggregate Angularity Two Crushed Faces	Tex-460-A, Part I, Determining Crushed Face Count	90% Min.
Flat Elongated Particles	ASTM D4791 Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate	20% Max. @ 3:1

1. Sampled during delivery to the plant or from the stockpile, unless otherwise shown on the plans.

302.2.3. Fine Aggregate. Fine aggregate may consist of crushed stone, crushed gravel, sand, and/or limestone or steel slag screenings.

Fine aggregate shall meet the requirements listed in Table 302.2.3.(a) Fine Aggregate Quality Requirements.

Table 302.2.3.(a) Fine Aggregate Quality Requirements[1]

Characteristic	Test Method	Value
Linear Shrinkage	Tex-107-E, Determining the Bar Linear Shrinkage of Soils	3% Max.
Sand Equivalent Value	Tex-203-F, Sand Equivalent Test	45% Min.

1. Sampled during delivery to the plant or from the stockpile, unless otherwise shown on the plans.

302.2.3.1. Sand. Sand material may constitute a part of the fine aggregates for hot-mix asphalt pavement. The fine aggregate portion of the sand passing the No. 40 (425-µm) sieve shall meet the Linear Shrinkage requirement listed in Table 302.2.3.(a) Fine Aggregate Quality Requirements.

302.2.3.1.1. Gradation. Fine aggregate sand shall be that portion of the sand in the total aggregate passing the No. 10 (2.0mm) sieve. It shall be well graded and composed of sound, durable sand particles.

302.2.3.2. Limestone or Steel Slag Screenings. Limestone or steel slag screenings may constitute part or all of the fine aggregates for hot-mix asphalt pavement. Screenings shall be of the same or similar material for coarse aggregates. Where limestone rock screenings are specified for use, they shall be screenings resulting from crushing operation.

The fine aggregate portion passing the No. 40 (425-µm) sieve shall meet the Linear Shrinkage requirement listed in Table 302.2.3.(a) Fine Aggregate Quality Requirements. Fine aggregates from each source shall meet Linear Shrinkage requirements.

302.2.3.2.1. Gradation. The limestone or steel slag screening shall meet the grading requirements in Table 302.2.3.2.1.(a) Limestone or Steel Slag Screenings Gradation unless otherwise shown on the plans.

When authorized by the OWNER, stone or steel slag screenings containing particles larger than ⅜-in. (9.5-mm) may be used but only that portion of the material passing the ⅜-in. (9.5-mm) sieve shall be considered as fulfilling the requirements for screenings when a minimum percent of screenings is specified for a particular mixture.

Table 302.2.3.2.1.(a) Limestone or Steel Slag Screenings Gradation

Sieve Size	Percent Passing by Weight
⅜-in. (9.5-mm)	100
Passing No. 200 (75-µm)	0 to 30

302.2.4. Mineral Filler. Mineral filler shall consist of a thoroughly dry stone dust Portland cement or other mineral dust approved by the OWNER. All mineral filler shall meet the requirements listed in Table 302.2.4.(a) Mineral Filler Quality Requirements.

Table 302.2.4.(a) Mineral Filler Quality Requirements[1]

Characteristic	Test Method	Value
Linear Shrinkage	Tex-107-E, Determining the Bar Linear Shrinkage of Soils	3% Max.

1. Sampled during delivery to the plant or from the stockpile, unless otherwise shown on the plans.

302.2.4.1. Gradation. When tested by the method outlined in TxDOT Test Method Tex-200-F Sieve Analysis of Fine and Coarse Aggregates (Part 1 Dry Sieve Analysis (Based on Weight) or Part 3 Volumetric Sieve Analysis, as applicable), it shall meet the requirements of Table 302.2.4.1.(a) Mineral Filler Gradation.

Table 302.2.4.1.(a) Mineral Filler Gradation

Sieve Size	Percent Passing by Weight
No. 30 sieve (600-µm)	95 to 100
No. 80 sieve (180-µm)	Not Less Than 75
No. 200 sieve (75 µm)	Not Less Than 55

302.3. BITMINOUS MATERIALS

302.3.1. General. This Item consists of bituminous material, including performance graded asphalts, modified performance graded asphalts, asphalt cement, emulsified asphalt, and other miscellaneous asphaltic materials. Asphalt for use in paving shall be a refined asphalt produced from crude petroleum. The base asphalt shall be homogeneous and free from water and residue from distillation of coal, coal tar or paraffin oil and shall not foam when heated to 347°F.

302.3.1.1. Tests and Certification of Bituminous Materials. When tested according to ASTM or AASHTO test methods, the various materials shall meet the applicable requirements of this specification. At the time of delivery of each shipment of asphalt, the vendor supplying the material shall deliver to the CONTRACTOR certified copies of the test report. Two copies of the test reports shall be furnished to the OWNER. Test reports shall indicate the name of the vendor, type and grade of bituminous material delivered, date and point of delivery, quantity delivered, delivery ticket number, purchase order number, and results of the specified tests. The test report, signed by an authorized representative of the vendor, shall certify that the product delivered conforms to the specifications for the type and grade indicated. The certified test reports and the testing required in connection with the reports shall be at no cost to the OWNER.

Until the certified test reports and samples of the material have been checked by the OWNER to determine their conformity with the prescribed requirements, the material to which such report relates and any work in which it may have been incorporated as an integral component, shall be only tentatively accepted by the OWNER. Final acceptance shall be dependent upon the determination by the OWNER that the material involved fulfills the prescribed requirements.

302.3.1.2. Rejection. Any material specified in this section may be rejected for failure to meet any of the provisions for this specification, or for any defect causing it to be unsuitable for its intended use.

302.3.2. Performance Graded (PG) Asphalt Binders. Performance graded asphalt binders shall be smooth and homogeneous, shall be free from water, shall not foam when heated to 347°F and shall meet the

requirements for performance graded asphalt binders shown in Table 302.3.2.(a) Performance Graded Asphalt Binders.

PG binders shall show no separation when tested according to Tex-540-C Measurement of Polymer Separation on Heating in Modified Asphalt Systems. Separation testing is not required if one of the following conditions is met:

(1) The modifier is introduced separately at the mix plant either by injection in the asphalt line or mixer; or
(2) The binder is blended on site in continuously agitated tanks; or
(3) Binder acceptance is based on field samples taken from an in-line sampling port at the hot-mix plant after the addition of modifiers.

302.3.2.1. Modified Performance Graded Asphalt Binders. In addition to meeting the requirements in Table 302.3.2.(a) Performance Graded Asphalt Binders, modified performance graded asphalt binders shall also meet the requirements listed herein according to grade.

302.3.2.1.1. SBR Latex Rubber Modified Performance Graded Binders. Available grades include PG 64-28L, PG 70-28L, PG 70-22L, PG 76-22L, and PG 82-22L. The manufacturer shall provide certification that SBR latex rubber was used in production of the binder. Ductility tested according to AASHTO T51: 39.2°F, 1-cm/min, cm, 70-cm minimum.

302.3.2.1.2. SBS Rubber Modified Performance Graded Binders. Available grades include PG 64-28S, PG 70-28S, PG 70-22S, PG 76-22S, and PG 82-22S. The manufacturer shall provide certification that SBS rubber was used in production of the binder. Elastic recovery tested according to Tex-539-C Measurement of Elastic Recovery of Tensile Deformation Using a Ductilometer: 50°F, 55% minimum.

302.3.2.1.3. Tire Rubber Modified Performance Graded Binders. Available grades include PG 64-28TR, PG 70-28TR, PG 70-22TR, PG 76-22TR, and PG 82-22TR. The manufacturer shall provide certification that tire rubber was used in production of the binder. Elastic recovery tested according to Tex-539-C Measurement of Elastic Recovery of Tensile Deformation Using a Ductilometer: 50°F, 40% minimum.

Table 302.3.2.(a) Performance Graded Asphalt Binders

Performance Grade	PG 58			PG 64				PG 70				PG 76				PG 82		
	-22	-28	-34	-16	-22	-28	-34	-16	-22	-28	-34	-16	-22	-28	-34	-16	-22	-28
Average 7-day maximum Pavement Design Temperature, °C[1]	58			64				70				76				82		
Minimum Pavement Design Temperature, °C[1] (i.e. design temperature shall be greater than shown)	-22	-28	-34	-16	-22	-28	-34	-16	-22	-28	-34	-16	-22	-28	-34	-16	-22	-28
Original Binder																		
Flash Point Temperature, AASHTO T48: Minimum °C	230																	
Viscosity, AASHTO TP48[2,3] Maximum, 3.0 Pa*s, Test Temp, °C	135																	
Dynamic Shear, AASHTO TP5:[4] G*/sinδ, Minimum, 1.00-kPa Test Temperature @ 10-rad/s, °C	58			64				70				76				82		
Rolling Thin Film Oven (Tex-541-C)																		
Maximum Loss, percent	1.0																	
Dynamic Shear, AASHTO TP5: G*/sinδ, Minimum, 2.20-kPa Test Temperature @ 10-rad/s, °C	58			64				70				76				82		
Pressure Aging Vessel Residue (AASHTO PP1)																		
PAV Aging Temperature, °C	100																	
Dynamic Shear, AASHTO TP5: G*/sinδ, Maximum, 5000-kPa Test Temperature @ 10-rad/s, °C	25	22	19	28	25	22	19	28	25	22	19	28	25	22	19	28	25	22
Creep Stiffness, AASHTO TP1:[5,6] *S*, Maximum, 300-Mpa *m*-value, Minimum, 0.300 Test Temp @60s, °C	-12	-18	-24	-6	-12	-18	-24	-6	-12	-18	-24	-6	-12	-18	-24	-6	-12	-18
Direct Tension, AASHTO TP3:[6] Failure Strain, Minimum, 1.0% Test Temp @ 1.0-mm/min, °C	-12	-18	-24	-6	-12	-18	-24	-6	-12	-18	-24	-6	-12	-18	-24	-6	-12	-18

1. Pavement temperatures are estimated from air temperatures using an algorithm contained in the PGEXCEL3.XLS software program, may be provided by the specifying agency, or by following the procedures as outlined in AASHTO MP2 and PP28.
2. This requirement may be waived at the discretion of the specifying agency if the supplier warrants that the asphalt binder can be adequately pumped, mixed and compacted at temperatures that meet all applicable safety, environmental and constructability requirements. At test temperatures where the binder is a Newtonian fluid, any suitable standard means of viscosity measurement may be used, including capillary (AASTHO T201 or T202) or rotational viscometry (AASHTO TP48).
3. Viscosity at 135°C is an indicator of mixing and compaction temperatures that can be expected in the lab and field. High values may indicate high mixing and compaction temperatures. Additionally, significant variation can occur from batch to batch. CONTRACTORS should be aware that variation could significantly impact mixing and compaction operations. CONTRACTORS are therefore responsible for addressing any constructability issues which may arise.
4. For quality control of unmodified asphalt cement production, measurement of the viscosity of the original asphalt cement may be substituted for dynamic shear measurements of G*/sin(δ) at test temperatures where the asphalt is a Newtonian fluid. Any suitable standard means of viscosity measurement may be used, including capillary (AASHTO T201 or T202) or rotational viscometry (AASHTO TP48).
5. Silicone beam molds as described in AASHTO TP1-93 are acceptable for use.
6. If the creep stiffness is below 300-Mpa, the direct tension test is not required. If the creep stiffness is between 300- and 600-Mpa, the direct tension failure strain requirement can be used in lieu of the creep stiffness requirement. The m-value requirement must be satisfied in both cases.

302.3.2.2. Acceptance of Performance Graded (PG) Asphalt Binders.

302.3.2.2.1. Location of Manufacture. Performance graded binder acceptance procedures are dependent on where the binder is manufactured. The requirements are as follows.

Manufactured at the Source. PG binders manufactured at the source are normally approved at the source according to the applicable requirements of the OWNER. The OWNER may acquire field samples at any time, particularly if material quality is suspect.

Manufactured at the Job Site. If PG binders are manufactured at the job site, for example where SBR latex is injected at the hot mix plant, the following quality measures are required. Antistrip agents are not considered asphalt modifiers.

(1) Preconstruction. The CONTRACTOR shall provide the OWNER with a 1-quart sample of the proposed binder and a test report showing compliance with the required performance grade. The sample and test report will be forwarded to OWNER for verification testing. If the OWNER chooses to verify that the sample meets specifications, the OWNER will complete verification testing within ten (10) working days after receipt of the sample. If the OWNER chooses to verify the sample, then the sample shall be verified before mixture production is allowed to begin.

(2) Construction. A sampling port is required which meets the requirements of AASHTO T40 Practice for Sampling Bituminous Materials, Section 9, “Sampling From Pipelines During Loading or Unloading”. This sampling port shall be located on the asphalt line before introduction of the asphalt into the mix plant and shall be downstream from the addition of any modifiers and any dispersing or mixing equipment associated with their introduction.

Sample containers shall be provided by the CONTRACTOR and shall be clean, double friction top round 1-quart cans. All samples shall be taken by the CONTRACTOR, and witnessed by the Engineer.

All samples shall be taken from the sampling port after a sufficient amount of asphalt is run out and wasted, in order to clear any residual asphalt that builds up in the sampling port. All samples shall be taken in a clean, 1-gallon can, immediately stirred and used to fill three (3) 1-quart sample cans. The cans shall be delivered to the OWNER. The OWNER will choose one sample can for testing and the other cans are retained until testing is complete, in case the original sample is lost or damaged.

302.3.2.2.2. Sampling Frequency. A sample of the PG binder may be taken from each mixture production day, at a time determined by the OWNER. The sample from the first day’s production may be subjected to verification testing. Additionally, throughout the duration of the project, the OWNER may randomly select binder samples for verification testing.

302.3.2.2.3. Verification Testing. OWNER may perform verification testing on all construction samples. The OWNER will complete verification testing within 10 working days after receipt of the sample.

For verification testing which fails to confirm the required performance grade, the CONTRACTOR shall review the manufacturing process to locate the source of the problem. The OWNER may stop production until the CONTRACTOR can show that the next binder produced will meet the specifications. The OWNER may require materials not meeting the specification requirements to be removed and replaced at the CONTRACTOR's expense.

302.3.3. Asphalt Cement. Asphalt cement is bituminous liquid binder. The material for asphalt cement shall be homogeneous, shall be free from water, shall not foam when heated to 347°F and shall meet the requirements of Table 302.3.3.(a) Requirements for Asphalt Cement.

Table 302.3.3.(a) Requirements for Asphalt Cement

Property, Test Parameters	Value According to Grade							
	AC-3		AC-5		AC-10		AC-20	
	Min	Max	Min	Max	Min	Max	Min.	Max
Viscosity, 140°F , Stokes	250	350	400	600	800	1200	1600	2400
Viscosity, 275°F, Stokes	1.1	—	1.4	—	1.9	—	2.5	—
Penetration, 77°F, 100-g, 5-sec.	210	—	135	—	85	—	55	—
Flash point C.O.C., °F	425	—	425	—	450	—	450	—
Solubility in trichloroethylene (%)	99.0	—	99.0	—	99.0	—	99.0	—
Tests on residues from thin film oven test: Viscosity, 140°F, Stokes	—	900	—	1500	—	3000	—	6000
Ductility, 77°F 5-cms-per-min, cms.	100	—	100	—	70	—	50	—
Spot Test	Negative for all grades							

302.3.3.1. Polymer Modified Asphalt Cement. For surface treatment applications, a polymer additive consisting of an anionic emulsion of styrene-butadiene low-temperature copolymer shall be added to the AC-5 or AC-10 asphalt when specified on the plans or in the specifications in the contract. The polymer additive shall consist of two-percent (by weight) polymer additive (solids basis) which has good storage stability. Polymer additive shall possess the properties specified in Item 302.3.3.1.1. Polymer Additive Properties. The manufacturer shall furnish the actual styrene-butadiene rubber (SBR) content for each batch of polymer emulsion. This information shall accompany all shipments to facilitate proper addition rates.

The finished polymer modified asphalt cement blend shall be smooth, homogeneous, and comply with the requirements in Table 302.3.3.1.(a) Polymer Modified Asphalt Requirements.

Table 302.3.3.1.(a) Polymer Modified Asphalt Requirements

Property	Test Method, Test Parameters	Value According to Grade	
		AC-5 + 2% Polymer Solids	AC-10 + 2% Polymer Solids
Minimum SBR Content	Tex-533-C Determining Polymer Additive Percentages in Polymer Modified Asphalt Cements, IR Determination[1]	2.0% Solids By Wt.	2.0% Solids By Wt.
Penetration	AASHTO T49, 100-G, 5-Sec, 77°F	120 Min	80 Min
Minimum Viscosity	AASHTO T202, 140°F	700-Poise	1300-Poise
Maximum Viscosity	AASHTO T202, 275°F	7.0-Poise	8.0-Poise
Ductility	AASHTO T51, 39.2°F, 5-cm/Min	70-cm, Min	60-cm, Min
Separation of Polymer	Tex-540-C Measurement of Polymer Separation on Heating in Modified Asphalt Systems, After 48-Hrs. at 325°F	None	None

1. The asphalt supplier shall furnish the OWNER samples of the asphalt cement and polymer emulsion used in making the finished product.

302.3.3.1.1. Polymer Additive Properties.
The polymer additive shall be an emulsion of styrenebutadiene low-temperature copolymer in water. The emulsion shall have good storage stability and possess the properties in Table 302.3.3.1.1.(a) Polymer Additive Requirements.

Table 302.3.3.1.1.(a) Polymer Additive Requirements

Property	Value
Monomer Ratio of Polymer (butadiene to styrene)	73 ± 5 27 ± 5
Minimum Solids Content (percent by weight)	45
Viscosity of Emulsion at 77 ± 1°F, cps, max (No.3 spindle, 20-rpm, Brookfield RVT Viscometer)	2000

302.3.4. Emulsified Asphalt. Emulsified asphalt shall be composed of a paving asphalt base uniformly emulsified with water. It shall be homogeneous throughout and, when stored, shall show no separation within 30-days after delivery. Emulsified asphalt shall meet the requirements for the specified type and grade shown in Tables 302.3.4.(a) through (d).

302.3.4.1. Testing Requirements. Test reports and certification shall be made for emulsified asphalt in accordance with Item 302.3.1.1. Tests and Certification of Bituminous Materials.

302.3.4.2. Temperature. Emulsified asphalt may be reheated, but at no time after loading for transportation from refinery to the purchaser shall the temperature of the emulsion be raised above 160°F. During reheating, the emulsified asphalt shall be agitated to prevent localized overheating. Emulsified asphalt shall not be permitted to cool to a temperature of less than 40°F. Unless otherwise specified, emulsified asphalt shall be applied at a temperature within the limits specified in Table 302.5.(a) Requirements for Storage, Heating and Application Temperature. CONTRACTOR shall furnish and keep on the site an accurate thermometer suitable for determining the temperature of the emulsified asphalt.

Table 302.3.4.(a) Tests and Properties of Anionic Emulsions

Property	Rapid Setting				Medium Setting		Slow Setting			
	Type - Grade									
	RS-2		RS-2h		MS-2		SS-1		SS-1h	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Viscosity, Saybolt Furol at 77°F, sec	-	-	-	-	-	-	20	100	20	100
at 122°F, sec	150	400	150	400	100	300	-	-	-	-
Sieve Test, %	-	0.10	-	0.10	-	0.10	-	0.10	-	0.10
Miscibility (Standard Test)	-	-	-	-	-	-	Passing		Passing	
Cement Mixing, %	-	-	-	-	-	-	-	2.0	-	2.0
Demulsibility, 35-ml of 0.02 N $CaCl_2$, %	60	-	60	-	-	30	-	-	-	-
Storage Stability, 1-day, %	-	1	-	1	-	1	-	1	-	1
Freezing Test, 3 cycles[1]	-	-	-	-	Passing		Passing		Passing	
Distillation Test:										
Residue by Distillation, % by weight	65	-	65	-	65	-	60	-	60	-
Oil Distillate, % by volume of emulsion	-	½	-	½	-	½	-	½	-	½
Tests on Residue from Distillation:										
Penetration at 77°F, 100 g, 5 sec	120	160	80	110	120	160	120	160	70	100
Solubility in Trichloroethylene, %	97.5	-	97.5	-	97.5	-	97.5	-	97.5	-
Ductility at 77°F, 5 cm/min, cm	100	-	80	-	100	--	100	-	80	-

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

Table 302.3.4.(b) Tests and Properties of High Float Anionic Emulsions

Property	Rapid Setting		Medium Setting	
	Type - Grade			
	HFRS-2		AES-300	
	Min	Max	Min	Max
Viscosity, Saybolt Furol at 77°F, sec	-	-	75	400
at 122°F, sec	150	400	-	-
Sieve Test, %	-	0.10	-	0.10
Coating Ability and Water Resistance:				
Coating, dry aggregate	-	-	good	
Coating, after spraying	-	-	fair	
Coating, wet aggregate	-	-	fair	
Coating, after spraying	-	-	fair	
Demulsibility 35-ml of 0.02 N $CaCl_2$, %	50	-	-	-
Storage Stability Test, 1-day, %	-	1	-	1
Distillation Test:				
Residue by Distillation, % by weight	65	-	65	-
Oil Distillate, by volume of emulsion, %	-	1/2	-	5
Tests on Residue from Distillation:				
Penetration at 77°F, 100 g, 5 sec	100	140	300	-
Solubility in Trichloroethylene, %	97.5	-	97.5	-
Ductility at 77°F, 5 cm/min, cm	100	-	-	-
Float Test at 140°F, sec	1200	-	1200	-

Table 302.3.4.(c) Tests and Properties of Cationic Emulsions

Property	Rapid Setting				Medium Setting				Slow Setting			
	Type - Grade											
	CRS-2		CRS-2h		CMS-2		CMS-2s		CSS-1		CSS-1h	
	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Viscosity, Saybolt Furol												
at 77°F, sec	-	-	-	-	-	-	-	-	20	100	20	100
at 122°F, sec	150	400	150	400	100	300	100	300	-	-	-	-
Sieve Test, %	-	0.10	-	0.10	-	0.10	-	0.10	-	0.10	-	0.10
Cement Mixing, %	-	-	-	-	-	-	-	-	-	2.0	-	2.0
Demulsibility, 35 ml 0.8 percent												
sodium dioctyl sulfosuccinate, %	40	-	40	-	-	-	-	-	-	-	-	-
Storage Stability, 1 day, %	-	1	-	1	-	1	-	1	-	1	-	1
Coating Ability and Water Resistance:												
Coating, dry aggregate	-	-	-	-	good		good		-	-	-	-
Coating, after spraying	-	-	-	-	fair		fair		-	-	-	-
Coating, wet aggregate	-	-	-	-	fair		fair		-	-	-	-
Coating, after spraying	-	-	-	-	fair		fair		-	-	-	-
Particle Charge Test	positive		positive		positive		positive		positive		positive	
Distillation Test:												
Residue by Distillation, % by wt	65	-	65	-	65	-	65	-	60	-	60	-
Oil Distillate, % by volume of Emulsion	-	½	-	½	-	7	-	5	-	½	-	½
Tests on Residue from Distillation:												
Penetration at 77°F,100-g,5-sec	120	160	80	110	120	200	300	-	120	160	80	110
Solubility in Trichloroethylene, %	97.5	-	97.5	-	97.5	-	97.5	-	97.5	-	97.5	-
Ductility at 77° F, 5 cm/min, cm	100	-	80	-	100	-	-	-	100	-	80	-

Table 302.3.4.(d) Tests and Properties of Polymer Modified Emulsions

Property	High Float Anionic Rapid Setting		Cationic Rapid Setting	
	Type - Grade			
	HFRS-2P		CRS-2P	
	Min	Max	Min	Max
Polymer Content, percent by weight of the distillation residue [1]	3.0	-	3.0	-
Viscosity, Saybolt Furol at 122°F, sec	150	400	150	400
Storage Stability Test, 1-day, %	-	1	-	1
Demulsibility, 35-ml of 0.02 N $CaCl_2$, %	40	-	-	-
Demulsibility, 35-ml 0.8-percent sodium dioctyl sulfosuccinate, %	-	-	40	-
Sieve Test, %	-	0.10	-	0.10
Particle Charge Test	-		Positive	
Distillation Test:[2]				
Oil distillate, by volume of emulsion, %	-	½	-	½
Residue, % by wt	65	-	65	-
Tests on Residue from Distillation:				
Float Value at 140°F, sec	1200	-	-	-
Penetration, 77°F, 100-g, 5-sec	100	140	110	150
Ductility, 39.2°F, 5-cm/min, cm	50	-	50	-
Viscosity at 140°F, poises	1500	-	1300	-
Solubility in Trichloroethylene, %	97	-	97	-

1. The CONTRACTOR shall provide the OWNER samples of the asphalt cement and polymer used in making the finished emulsion with a certified statement from the Emulsion Supplier stating that the provided asphalt cement and polymer used in the finished product are the same as provided.
2. The temperature on the lower thermometer shall be brought slowly to 350°F plus or minus 10°F and maintained at this temperature for 20-minutes. The total distillation shall be completed in 60-minutes plus or minus 5-minutes from the first application of heat.

302.3.5. Emulsions for Priming, Curing and Erosion Control (PCE).

302.3.5.1. General Use Emulsions. The emulsion shall be a slow curing anionic or cationic emulsion of a petroleum based material in water. The supplier must state whether the material supplied is cationic or anionic. Such emulsions may be used for priming of base materials, curing seal for stabilized base materials, and erosion control applications such as dust control, soil surface stabilization, or mulch binder.

Emulsion properties shall fall within the ranges as shown in Table 302.3.5.1.(a) Tests and Properties of PCE (General Use) Emulsions. The base emulsion material may be diluted with water to achieve the desired concentration of residual with maximum dilution rates as indicated in Table 302.3.5.1.(b) Maximum Dilution Rate.

Table 302.3.5.1.(a) Tests and Properties of PCE (General Use) Emulsions

Property	Test Methods, Test Parameters	Minimum	Maximum
Viscosity	Saybolt Furol, 25°C	10-seconds	100-seconds
Sieve Test	Sieve Test	-	0.1%
Miscibility	ASTM D244 Emulsified Asphalts, modified[1]	Passing	-
Residue by Evaporation	ASTM D244, modified[2]	60% by weight	-
Tests on Residue from Evaporation	Flash Point, C.O.C. Kinematic Viscosity, 60°C	200°C 100-cSt	- 350-cSt

1. Except the dilution shall use 350-ml of distilled or deionized water and a 100-ml beaker.
2. Except the sample shall remain in the oven until foaming ceases, then cooled and weighed.

Table 302.3.5.1.(b) Maximum Dilution Rate

Use	Maximum Dilution Rate
Priming of Base Materials	(1) part PCE to (3) parts water
Curing Seal	(1) part PCE to (3) parts water
Erosion Control	(1) part PCE to (7) parts water

302.3.5.2. Emulsions Specifically for Priming and Curing. Product shall be a water-based emulsion composed of petroleum of resin oil base with selective hardening and drying agents to form a road prime and sealer. Emulsions may be provided either concentrated or pre-diluted. Concentrated prime and/or road sealing emulsions specified in this Item 302.3.5.2. Emulsions Specifically for Priming and Curing shall meet the requirements of Table 302.3.5.2.(a) Requirements for MCS-600-C – Concentrated. Diluted prime and/or road sealing emulsions specified in this Item 302.3.5.2. Emulsions Specifically for Priming and Curing shall meet the requirements of Table 302.3.5.2.(b) Requirements for MCS-600-D – Dilute.

Table 302.3.5.2.(a) Requirements for MCS-600-C – Concentrated

Property	Test Methods, Test Parameters	Required Value	
		Minimum	Maximum
Appearance	Visual Inspection	Brown Liquid	
Viscosity S.F. at 77°F Sec	ASTM D244 Emulsified Asphalts	15	200
Residue, % min	ASTM D244, modified[1]	56	65
Miscibility Test	ASTM D244, modified[2]	No coagulation	
Moisture, wt %		-	48
Volatile %		35	-
% Non-Volatile Soluble in Trichloroethylene	AASHTO T 45-56	-	6
Accelerated Weathering (2-year exposure)	Federal Spec TT C-555 B, 40 ml	No material deterioration after exposure	
Resistance To wind and Driven Rain (@ 98 mph)	Federal Spec TT C-555 B, As 4ml sealer after cure	Passes/no wt. gain	
Ash, % wt.		-	8
Polymer, % wt.		-	4
Freeze Test (Concentrated Form)	3-cycle	Pass	
Particle Charge	ASTM D244	Positive	
Shaker Test 2- to 4-hrs.	Mix Burrell Wrist Action Shaker Model 75 set on Level 7, diluted 1 part water to 4 parts road prime, Sieve #40	-	1%

1. ASTM D244 Modified Evaporation Test for percent of residue is made by heating 50-gram sample to 300°F until foaming ceases, then cool immediately and calculate results.
2. Test procedure identical with ASTM D244, except that 0.02 Normal Calcium Chloride solution shall be used in place of distilled water.

Table 302.3.5.2.(b) Requirements for MCS-600-D – Dilute

Property	Test Methods, Test Parameters	Required Value	
		Minimum	Maximum
Appearance	Visual Inspection	Brown Liquid	
Viscosity S.F. at 77°F Sec	ASTM D244 Emulsified Asphalts	5	70
Residue, % min	ASTM D244, modified[1]	10	20
Miscibility Test	ASTM D244, modified[2]	No coagulation	
Moisture, wt %		-	90
Volatile %		90	-
% Non-Volatile Soluble in Trichloroethylene	AASHTO T 45-56	0	2
Accelerated Weathering (2-year exposure)	Federal Spec TT C-555 B, 40 ml	No material deterioration after exposure	
Resistance To wind and Driven Rain (@ 98 mph)	Federal Spec TT C-555 B, As 4ml sealer after cure	Passes/no wt. gain	
Ash, % wt.		-	2
Polymer, % wt.		-	1
Freeze Test (Concentrated Form)	3-cycle	Pass	
Particle Charge	ASTM D244	Positive	
Shaker Test 2- to 4-hrs. (non-diluted)	Mix Burrell Wrist Action Shaker Model 75 set on Level 7, Sieve #40	-	1%

1. ASTM D244 Modified Evaporation Test for percent of residue is made by heating 100-gram sample to 300°F until foaming ceases, then cool immediately and calculate results.
2. Test procedure identical with ASTM D244, except that 0.02 Normal Calcium Chloride solution shall be used in place of distilled water.

302.3.6. Specialty Emulsions. Specialty emulsions shall be slow setting emulsions of a petroleum-based material in water. Specialty emulsions may be used for purposes such as tack coat, fog seals, priming base materials, curing seal for stabilized base materials, recycled/reclaimed asphalt pavement (RAP) rejuvenator, repairing surface deficiencies, and erosion control applications. Specialty emulsions are classified as either Restorative Seal or Maltene Rejuvenator and shall meet the requirements for the specified type shown in Table 302.3.6.(a) Requirements for Restorative Seal or Table 302.3.6.(b) Requirement for Maltene Rejuvenator, respectively. Specialty emulsions shall be freeze stabilized and if freezing has occurred a homogeneous mixture shall be obtained when the material has thawed and been thoroughly mixed.

Table 302.3.6.(a) Requirements for Restorative Seal

Properties	Test Methods	Requirements
Test on Emulsion		
Viscosity @77°F, SES	ASTM D244 Emulsified Asphalts	25 - 150
Sieve Test, % by Wt.	ASTM D244, modified[1]	0.1 Max.
Particle Charge Test	ASTM D244	Positive
Cement Mixing Test, % by Wt.	ASTM D244	2.0 Max.
Pumping Stability	See Note 2.	Pass
5-day Settlement Test, % by Wt.	ASTM D244	5.0 Max.
Residue, % Wt.	ASTM D244, modified[3]	64 Min.
Test on Residue from Distillation		
Viscosity @ 140°F, cSt	ASTM D2170 Kinematic Viscosity of Asphalts (Bitumens)	1,000 – 4,000
Maltene Distribution Ratio[4]	ASTM D2006-70 Method of Test for Characteristic Groups in Rubber Extender and Processing Oils by the Precipitation Method (Discontinued 1975)	0.7 – 1.1
PC/S Ratio[4]	ASTM D2006-70	0.5 Min.
Asphaltenes, % Wt.	ASTM D2006-70	11.00 Max.

1. Test procedure identical with ASTM D244 except that distilled water shall be used in place of two-percent sodium oleate solution.
2. Pumping stability is determined by charging 15-ounces (450-ml) of emulsion into 30-ounce (one-liter) beaker and circulating the emulsion through a gear pump (Roper 29.B22621) having ¼" inlet and outlet. The emulsion passes if there is not significant oil separation after circulating ten-minutes.
3. ASTM D244 Evaporation Test for percent of residue is modified by heating 2-ounces (50-gram) sample to 300°F until foaming ceases, then cooling immediately and calculating results.
4. In the Maltene Distribution Ratio Test by ASTM Method D2006-70:

$(PC + A_1) \div (S + A_2)$

PC=Polar Compounds A_1=First Acidaffins

A_2= Second Acidaffins S= Saturated Hydrocarbons

Table 302.3.6.(b) Requirement for Maltene Rejuvenator

Properties	Test Methods		Requirements	
	ASTM	AASHTO	Min.	Max.
Test on Emulsion				
Viscosity @77°F, SES	D244 Emulsified Asphalts	T-59	15	40
Residue, % Wt.	D244 (Mod)[1]	T-59 (Mod)	60	65
Miscibility Test	D244 (Mod)[2]	T-59 (Mod)	No Coagulation	
Sieve Test, % by Wt.	D244 (Mod)[3]	T-59 (Mod)	-	0.1
Particle Charge Test	D244	T-59	Positive	
Percent Light Transmittance	See Note 4.		-	30
Test on Residue from Distillation				
Flash Point, COC, °F	D92 Flash and Fire Points by Cleveland Open Cup	T-48	385	-
Viscosity @ 140°F, cSt	D445 Kinematic Viscosity of Transparent and Opaque Liquids (the Calculation of Dynamic Viscosity)	-	100	200
Asphaltenes, % Wt.	D2006-70 Method of Test for Characteristic Groups in Rubber Extender and Processing Oils by the Precipitation Method (Discontinued 1975)	-	-	1.0
Maltene Distribution Ratio[5]	D2006-70		0.3	0.6
PC/S Ratio[5]	D2006-70	-	0.5	-
Saturated Hydrocarbons, S[5]	D2006-70	-	21	28

1. ASTM D244 Modified Evaporation Test for percent of residue is made by heating 2-ounces sample to 300°F until foaming ceases, then cool immediately and calculate results.
2. Test procedure identical with ASTM D244 except that 0.02 Normal Calcium Chloride solution shall be used in place of distilled water.
3. Test procedure identical with ASTM D244 except that distilled water shall be used in place of two-percent sodium oleate solution.
4. Test according to Attachment "Standard Procedure for Determining Percent Light Transmittance of Maltene Rejuvenator, Restorative Seal, and PCE Material" in TxDOT Special Provision to Item 300 for Maltene Rejuvenator (Waco District).
5. Chemical composition by ASTM Method D2006-70:
   $(PC + A_1) \div (S + A_2)$
   PC=Polar Compounds A_1=First Acidaffins
   A_2= Second Acidaffins S= Saturated Hydrocarbons

302.3.7. Emulsion for In-Place Asphalt Recycling. Emulsion shall be designed to be a recycling agent to be mixed at ambient temperature with existing in-place asphalt, native or selective material and or Recycled Asphalt Pavement (RAP) material. Product shall be a water miscible emulsion. Asphaltene, Resins, Cyclics, Saturates content must be specifically formulated based on laboratory data of existing material in relation to rejuvenation demand and any added RAP material. Product shall meet minimums and fall within the ranges specified in Table 302.3.7.(a) Emulsion Requirements for In-Place Asphalt Recycling.

Table 302.3.7.(a) Emulsion Requirements for In-Place Asphalt Recycling

Properties	Test Methods, Test Parameters	Requirements	
		Min.	Max.
Test on Emulsion			
Viscosity	Saybolt Furol, 122°F	-	185
Sieve %		-	1.0
Particle Charge		Positive	
Specific Gravity @ 77°F		0.910	1.16
Cement Mixing Test	ASTM D244	Passing	
Distillation			
Residue; % from Distillation @ 325°F		60	68
Test on Residue from Distillation			
Penetration, 77°F Extrapolation function		1400	-
Asphaltene, %		3.1	10.1
Resins, % wt.		1.2	8.9
Cyclics		65.0	95.0
Saturates		2.8	18.3
Flash Point C.O.C.		400°F	-

302.4. SECTION HELD FOR FUTURE USE

302.5. STORAGE, HEATING AND APPLICATION TEMPERATURE OF BITUMINOUS MATERIALS

Asphalt materials should be applied at the temperature that provides proper and uniform distribution. Within practical limits, higher temperatures than necessary should be avoided. Satisfactory application should be obtained within the recommended ranges shown in Table 302.5.(a) Requirements for Storage, Heating and Application Temperature. No material shall be heated above the maximum temperature shown. Performance graded asphalt binders containing particulate or polymer modifiers may be susceptible to separation of the modifier. Appropriate circulation or agitation in storage shall be provided if separation of the modifier is expected or suspected, and in every case when the modified binder will be stored at elevated temperatures for more than one day before use.

WARNING TO CONTRACTOR: Attention is called to the fact that asphaltic materials are highly flammable. Heating of asphaltic materials constitutes a fire hazard to various degrees. The utmost care shall be taken to prevent open flames of any kind from coming in contact with the asphaltic material or the gases of same. Proper precautions should be used in all cases. The CONTRACTOR shall be responsible for any fires or accidents which may result from heating the asphaltic materials.

Binder or modifier supplier instructions regarding recommended application and storage temperatures shall supersede the guidelines below.

Table 302.5.(a) Requirements for Storage, Heating and Application Temperature

Material Type-Grade	Application and Mixing		Heating and Storage
	Recommended Range °F	Maximum Allowable °F	Maximum °F
All PG Binders	275-375	375	400
AC-3, 5, 10, 20	275-325	350	400
Emulsions			
SS-1, SS-1h, SS-1P, CSS-1h	50-130	140	140
RS-2, RS-2h, MS-2, CRS2h, CRS-2P, CMS-2, CMS-2s, HFRS-2, HFRS-2P, AES-300	110-160	170	170
PCE, Restorative Seal or Maltene Rejuvenator	Ambient = 72-130	140	140

302.6. EMULSIFIED ASPHALT TREATMENT

302.6.1. Description. Emulsified asphalt treatment shall consist of one or more applications of a mixture of emulsified asphalt of the proportion and type specified on the plans and water. The mixture shall be applied at the rate specified on the plans. It is to be used as a base treatment, earthwork seal, prime coat or dust preventative. This mixture may be applied to the base course, subgrade, shoulders or detours at the locations and to the extent shown on plans or as directed by the OWNER.

302.6.2. Materials. The amount of emulsified asphalt in the mixture, expressed as a percent by volume of the total mixture, shall be within the limits specified on the plans. When tested by approved laboratory methods, the emulsified asphalt used shall meet the requirements of Item 302.3.4. Emulsified Asphalt or Item 302.3.5. Emulsions for Priming, Curing, and Erosion Control (PCE) or Item 302.3.6. Specialty Emulsions.

The water used shall be clear, free from industrial wastes and other objectionable matter.

302.6.3. Construction Methods. Asphalt materials shall be handled in accordance with Item 302.5. Storage, Heating and Application Temperature of Bituminous Materials.

The emulsified asphalt and water mixture shall be applied by a self-propelled sprinkler meeting the requirements of Item 203.6. Dust Control so operated as to uniformly distribute the mixture in the quantity determined by the OWNER.

The emulsion and water may be mixed in the sprinkler tank. The CONTRACTOR shall make suitable provisions for agitating the two materials sufficiently to produce a uniform blend. The sprinkler tank shall have been recently calibrated, and the OWNER shall be furnished an accurate and satisfactory record of such calibration. After beginning the work, should the yield on the emulsion applied appear to be in error, the distributor shall be recalibrated in a manner satisfactory to the OWNER, before proceeding with the work.

302.6.4. Measurement and Payment. Emulsified asphalt shall be measured by the gallon prior to mixing with water. The work performed and the emulsified asphalt furnished as prescribed by this Item and measured as provided in this Item shall be paid for at the unit price bid of the type specified, which price shall be full compensation for furnishing all required materials including mixing water for application; all freight involved; all hauling, mixing, and distributing the mixture as specified; and all manipulation, labor, tools, equipment and incidentals necessary to complete the work.

302.7. PRIME COAT

302.7.1. Description. This Item shall consist of application of asphaltic materials on the completed base course and/or other approved area, which shall be applied in accordance with these specifications and as shown of the plans.

302.7.2. Materials. The asphaltic material used for the prime coat shall be of the type and grade as stated in the contract and when tested by approved laboratory methods shall meet the requirements of Item 302.3.4. Emulsified Asphalt or Item 302.3.5. Emulsions for Priming, Curing, and Erosion Control (PCE) or Item 302.3.6. Specialty Emulsions.

302.7.3. Equipment. All storage tanks, piping, retorts, booster tanks and distributors used in storing and handling asphaltic material shall be kept clean and in good condition at all times. Equipment shall be operated in such a manner that there shall be no contamination of the asphaltic material with foreign material. It shall be the responsibility of the CONTRACTOR to provide and maintain in good working order a recording thermometer at the storage heating unit at all times. The distributor shall have been recently calibrated and the OWNER shall be furnished an accurate and satisfactory record of such calibration. After beginning the work, should the yield on the asphaltic material applied appear to be in error, the distributor shall be recalibrated in a manner satisfactory to the OWNER before proceeding with the work.

302.7.4. Construction Methods. Asphalt materials shall be handled in accordance with Item 302.5. Storage, Heating and Application Temperature of Bituminous Materials.

Prime coat shall not be applied when the air temperature is below 50°F and falling, but it may be applied when the air temperature is above 40°F and rising, the air temperature being taken in the shade and away from artificial heat. Asphaltic material shall not be placed when general weather conditions, in the opinion of the OWNER, are not suitable.

When, in the opinion of the OWNER, the base is thoroughly dry and is satisfactory to receive the prime coat, the surface shall be cleaned by sweeping or other methods approved by the OWNER. The asphaltic material shall be applied to the cleaned base at the approximate rate of 0.15- to 0.25-gallons-per-square-yard of surface area. The application shall be made with an approved type of self-propelled pressure distributor so constructed and operated as to distribute the material evenly and smoothly in the quantity specified or directed. The CONTRACTOR shall provide all necessary facilities for determining the temperature of the asphaltic material in all of the heating equipment and in the distribution, for determining the rate at which it is applied, and for securing uniformity at the junction of two distributor loads.

The OWNER shall select the temperature of application within the limits recommended in Item 302.5. Storage, Heating and Application Temperature of Bituminous Materials based on the temperature-viscosity relationship that shall permit application of the asphalt. The CONTRACTOR shall apply the asphalt at a temperature within 15°F of the temperature selected.

No traffic, hauling or placing of subsequent courses shall be permitted over the freshly applied prime coat until authorized by the OWNER.

The CONTRACTOR shall be responsible for the maintenance of the surface until the work is accepted by the OWNER.

302.7.5. Measurement and Payment. The asphaltic material for prime coat will be measured at the point of delivery on the road in gallons at the applied temperature. The quantity to be measured for payment shall be the number of gallons used, as directed, of the specified prime coat.

The work performed and materials furnished in accordance with this Item and measured as provided will be paid for at the unit prices bid for "Asphaltic Material," of the type and grade specified. Price shall be full compensation for cleaning the area to be primed; for furnishing, preparing, hauling and placing all required materials; for all freight and heating involved; for spreading, dragging, brooming, finishing and maintaining under traffic until accepted; and for all manipulation, labor, tools, equipment and incidentals necessary to complete the work.

302.8. ASPHALT BASE COURSE

302.8.1. Description. Asphalt base course shall consist of a compact mixture of mineral aggregates and asphaltic material mixed hot in a mixing plant. It may be a base course, subbase course, or foundation course. It is made of larger aggregate than Hot-Mix Coarse Base (A) as shown in Table 302.9.3.(a) Dense Graded Hot Mix Master Grading.

302.8.2. Materials.

302.8.2.1. Asphaltic Cement. Asphalt for the mixture shall be of the types of asphalt cement as determined by the OWNER and shall meet the requirements of Item 302.3.2. Performance-Graded (PG) Asphalt Binders or Item 302.3.3. Asphalt Cement. The grade of asphalt to be used shall be determined by the OWNER after design tests have been made using the mineral aggregate approved for use in the construction. If more than one type of asphaltic cement mixture is specified for the project, only one grade of asphalt shall be required for all types of mixture unless otherwise shown on the plans. The

CONTRACTOR shall notify the OWNER of the source of asphaltic material prior to production of the asphaltic mixture, and this source shall not be changed during the course of the project, except by written permission of the OWNER.

302.8.2.2. Tack Coat. The liquid asphalt material used for tack coat should be MS-2 or SS-1 in Item 302.3.4. Emulsified Asphalt, Restorative Seal in Item 302.3.6. Specialty Emulsions or one of the other various grades of materials (selected by the OWNER) listed under Item 302.3.4. Emulsified Asphalt.

302.8.2.3. Mineral Aggregate. The material shall be crushed and screened as necessary to meet the requirements hereinafter specified and shall consist of durable coarse aggregate particles mixed with approved binding materials.

Unless otherwise specified, the grading of the mineral aggregate shall conform to the limitations as shown in Table 302.8.2.3.(a) Asphalt Base Course Aggregate Grades.

Table 302.8.2.3.(a) Asphalt Base Course Aggregate Grades

Sieve Size	Grade			
	1	2	3	4
1 3/4-inch		100.0	100.0	As Shown on Plans
1 1/2-inch	100.0	90.0-100.0		
1-inch	90.0-100.0			
3/8-in.	45.0-70.0			
No. 4	30.0-55.0	25.0-55.0		
No. 40	15.0-30.0	15.0-40.0	15.0-40.0	

Testing of the mineral aggregate shall be in accordance with the test methods in Table 302.8.2.3.(b) Aggregate Tests.

Table 302.8.2.3.(b) Aggregate Tests

Property	Test
Preparation of Soil Constants	Tex-101-E Preparing Soil and Flexible Base Materials for Testing
Liquid Limit	ASTM D4318 Liquid Limit, Plastic Limit, and Plasticity Index of Soils
Plastic Limit	ASTM D4318 Liquid Limit, Plastic Limit, and Plasticity Index of Soils
Plasticity Index	ASTM D4318 Liquid Limit, Plastic Limit, and Plasticity Index of Soils
Sieve Analysis	ASTM C136 Sieve Analysis of Fine and Coarse Aggregates
Wet Ball Mill	Tex-116-E Ball Mill Method for Determining the Disintegration of Flexible Base Material
Sand Equivalent	ASTM D2419 Sand Equivalent Value of Soils and Fine Aggregate

Unless otherwise specified on the plans, the mineral aggregate for Grades 1, 2 and 3 shall meet the limits of Table 302.8.2.3.(c) Aggregate Physical Requirements. Mineral aggregate for Grade 4 shall meet the physical requirements shown on the plans.

Table 302.8.2.3.(c) Aggregate Physical Requirements

Property	Limit
Wet Ball Mill	50 Max.
Plasticity Index	15 Max.
Liquid Limit	40 Max.
Sand equivalent	≥ 40

302.8.3. Construction Methods. Asphalt materials shall be handled in accordance with Item 302.5. Storage, Heating and Application Temperature of Bituminous Materials.

Mixing plants may be either the weight-batching type plant, the continuous mixing type plant, or the drum mixing type plant as described in Item 302.9.5. Mixing Plants except that requirements for Type "B" and "D" mixtures of fine graded surface course are deleted.

Equipment for storage, weighing and heating of materials shall be as described in Item 302.9.4. Equipment.

The OWNER shall designate the asphalt content to be used in the mixture after design tests have been made with the aggregates to be used in the project. When tests as determined by the OWNER are made, samples of the mixture shall not vary from the asphalt content designated by the OWNER by more than 0.5-percent dry weight (based on total mixture). The asphaltic material will form typically 4- to 9-percent of the mixture by weight.

The mixture shall consist of a uniform mixture of mineral aggregates and asphaltic material.

The asphaltic mixtures for the weight-batching type plant and from the continuous mixing type plant, when tested in accordance with the current methods outlined in TxDOT Test Method Tex-208-F Test for Stabilometer Value of Bituminous Mixtures (Part I or Part III as applicable), shall have laboratory density and stability as indicated in Table 302.8.3.(a) Stability of Asphalt Base Course. If the mixture produced does not have the specified qualities, the mixture shall be changed until it conforms to the specified qualities.

Table 302.8.3.(a) Stability of Asphalt Base Course

Property	Value
Density (%)	96 ±2
Stability (%) Hveem Stabilometer	Not less than 40 except when otherwise shown on the plans

302.8.4. Measurement and Payment. Asphalt base course shall be measured and paid for in accordance with Item 302.10. Measurement and Payment.

302.9. HOT-MIX ASPHALT PAVEMENT

302.9.1. Description. This Item shall govern pavement consisting of a binder course, a leveling up course, a surface course or any combination of these courses as shown on the plans. Each course shall be composed of a compacted mixture of mineral aggregate and asphaltic material mixed hot in a mixing plant; and shall be constructed on the previously completed and approved subgrade, subbase course, base course, existing pavement, or in the case of a bridge, on the prepared floor slab, all in accordance with these specifications and in conformity with the lines, grades, quantities and typical sections as stated in the contract, plans and/or established in the field by the OWNER.

302.9.2. Materials. The materials proposed to be used may be inspected and tested at any time during the preparation of the work.

302.9.2.1. Aggregates. Mineral aggregates shall consist of a fine aggregate, coarse aggregate and, when required, a mineral filler all in accordance with Item 302.2. Aggregates for Hot-Mix Asphalt Pavement and approved by the OWNER. Representative samples of the materials proposed to be used in the mixture shall be submitted for tests in the quantities required by the OWNER. No material that has in any way become unfit for use after approval shall be used in the work. Approval of both the materials and sources of supply must be obtained from the OWNER prior to delivery of the material.

302.9.2.2. Asphaltic Materials. Material shall conform to the applicable paragraphs of Item 302.3. Bituminous Materials. Only one grade of asphalt shall be required for all the types of mixtures unless otherwise shown on the plans or required by the OWNER.

302.9.2.2.1. Paving Mixture. Asphaltic materials for the paving mixture shall be the type and grade specified, shown on the plans, or as designated by the OWNER after design tests have been made, using the mineral aggregates proposed to be used in the mixture, and shall meet the requirements of Item 302.3.2. Performance Graded (PG) Asphalt Binders or Item 302.3.3. Asphalt Cement. If more than one type of asphaltic pavement mixture is specified for the project, only one grade of asphalt

shall be required for all types of mixtures, unless otherwise shown on the plans. The CONTRACTOR shall notify the OWNER of the source of asphaltic material prior to production of the asphaltic mixture and prior to the paving of this course of the project except on written permission of the OWNER.

302.9.2.2.2. Prime Coat. Prime coat shall conform to the provisions of Item 302.7. Prime Coat.

302.9.2.2.3. Track Coat. The liquid asphalt material used for tack coat should be MS-2 or SS-1 in Item 302.3.4. Emulsified Asphalt, restorative seal in Item 302.3.6. Specialty Emulsions or one of the other various grades of materials (selected by the OWNER) listed under Item 302.3.4. Emulsified Asphalt.

302.9.3. Paving Mixture. The paving mixture shall consist of a uniform mixture of coarse aggregate, fine aggregate, mineral filler, when required, and asphaltic material, accurately proportioned by weight. The grading of each constituent shall be such as to produce, when properly proportioned, a mixture conforming to the following limitations for grading the type specified. The exact proportions of each constituent producing the total aggregate within these limits shall be as directed by the OWNER, and when tested by standard laboratory methods, the mixture shall meet the requirements listed in Tables 302.9.3.(a) through (f). The OWNER shall specify or approve a mixture within the specified limits for all types of mixtures, which shall be suitable for the work in which the asphaltic pavement shall be used. The percentages of asphalt shall not vary more than 0.4-percent from the proportions established by the OWNER.

Table 302.9.3.(a) Dense Graded Hot Mix[1] Master Grading

Sieve Size	Type of Mixture						
	A Coarse Base	B Fine Base	C Coarse Surface	D Fine Surface	F Fine Mixture	CMHB – C Coarse Surface	CMHB – F Fine Surface
	Percent Passing by Weight						
1½"	100						
1¼"	95-100						
1"		100					
⅞"	70-90	95-100	100			98 –100	
⅝"		75-95	95-100			95 –100	
½"	50-70			100			98 –100
⅜"		60-80	70-85	85-100	100	50-70	85 - 100
¼"					95-100		
No. 4	30-50	40-60	43-63	50-70		30 - 45	40 - 60
No. 10	20-34	27-40	30-40	32-42	32-42	15 - 25	15 - 25
No. 40	5-20	10-25	10-25	11-26	9-24	6 – 20	6 – 20
No. 80	2-12	3-13	3-13	4-14	3-13	6 – 18	6 – 18
No. 200	2 - 8	2 - 8	2 - 8	2 - 8	2 - 8	5 - 8	5 - 8
VMA % minimum	11	12	13	14	15	14	15

1. These mixtures shall be designed using a Texas Gyratory Compactor (TGC) and in accordance with Test Method Tex-204-F Design of Bituminous Mixtures. Design must be researched and based on intended use.

Table 302.9.3.(b) Superpave Hot Mix[1] Master Grading

Sieve Size, inches (centimeters)	Nominal Maximum Aggregate Size, inches (centimeters)				
	1½ (3.81)	1 (2.54)	¾ (1.90)	½ (1.27)	⅜ (0.95)
	Coarse Base	Fine Base	Coarse Surface	Fine Surface	Fine Mixture
	Percent Passing By Weight				
2 (5.08)	100.0				
1½ (3.81)	90.0 – 100.0	100.0			
1 (2.54)		90.0 – 100.0	100.0		
¾ (1.90)			90.0 – 100.0	100.0	
½ (1.27)				90.0 – 100.0	100.0
⅜ (0.95)					90.0 – 100.0
No. 4					
No. 8	15.0 - 41.0	19.0 – 45.0	23.0 - 49.0	28.0 – 58.0	32.0 – 67.0
No. 16					
No. 30					
No. 50					
No. 100					
No. 200	0.0–6.0	1.0 – 7.0	2.8 - 8.0	2.0 - 10.0	2.0 – 10.0
VMA % minimum	11	12	13	14	15

1. These mixtures shall be designed using a Superpave Gyratory Compactor (SGC) and in accordance with the AASHTO Standard Practice for Designing Superpave Hot Mix Asphalt (PP28-99). Design must be researched and based on intended use.

Table 302.9.3.(c) Superpave – Plant Produced Mixture Requirements

VMA (MIN)	VFA	Dust/Asphalt Ratio
11.0%	64 – 77 %	0.6 – 1.8 %
12.0%	67 – 77 %	0.6 – 1.6 %
13.0%	69 – 80 %	0.6 – 1.6 %
14.0%	71 – 80 %	0.6 – 1.6 %
15.0%	73 – 80 %	0.6 – 1.6 %

Table 302.9.3.(d) Cellulose Modified Mixtures[1] Master Grading

Sieve Size	Stone Mastic Asphalt (SMA)		Permeable Friction Course (PFC)	
	¾"	½"	½"	½" Modified
	Coarse Surface	Fine Surface	Coarse Surface	Fine Surface
	Percent Passing By Weight			
¾"	100.0			
½"	99.0-100.0	100.0	90.0-100.0	85.0-100.0
⅜"	70.0-85.0	70.0-90.0	35.0-60.0	55.0-75.0
No. 4	30.0-42.0	30.0-50.0	10.0-25.0	15.0-25.0
No. 8	20.0-33.0	20.0-30.0	5.0-10.0	5.0-10.0
No. 16		21.0 max		
No. 30		18.0 max		
No. 50		15.0 max		
No. 100				
No. 200	8.0-11.0	8.0-12.0	1.0 - 4.0	2.0 - 4.0

1. These mixtures shall be designed using a Superpave Gyratory Compactor (SGC) and in accordance with the AASHTO Standard Practice for Designing Superpave Hot Mix Asphalt (PP28-99). Design must be researched and based on intended use.

Table 302.9.3.(e) Cellulose Modified Mixture Properties

Property	Requirements	
	Stone Mastic Asphalt (SMA)	Permeable Friction Course (PFC)
Air Voids, %	4.0 (Lab Molded)	20.0 Min. (Lab Molded)
Cellulose Fibers, %	0.4	0.4
VMA, Percent (Min.)	17.0 (Plant); 17.5 (Design)	
VCA[1] (Mix), Percent	Less Than VCA (DRC)	
TSR, Percent	80.0 Min. (Tex-531-C)	
Draindown @ Production Temp., %	0.30 Max. (T305)	0.30 Max. (T305)
Asphalt Content, Percent	6.0 Min.	6.0 Min.
N(Des)	100	20

1. See NCHRP Report 425 for definition and calculation of VCA (Voids in Coarse Aggregate).

302.9.3.1. Extraction Test. When required by the OWNER, samples of the asphaltic mixture may be taken from the plant, trucks or finished pavement for check tests. The minimum weight of the test specimen in grams shall be 3000 times the maximum size of aggregate in inches, and when tested in accordance with Recovery of Asphalt from Solution by Abson Method and Quantitative Extraction of Bitumen from Bituminous Paving Mixtures, ASTM Designations D1856 and D2172, respectively, it shall not vary from the grading proportions specified for the mixture being used by more than 5-percent.

302.9.3.2. Stability. The asphaltic mixture from the weight-batching plant and from the continuous mixing type plant, when tested in accordance with the current methods outlined in the TxDOT Test Method Tex-208-F Test for Stabilometer Value of Bituminous Mixtures, shall have the laboratory density and stability indicated in Table 302.9.3.(f) Asphalt Pavement Mixture Stability. If the mixture produced does not have the specified qualities, the mixture shall be changed until it conforms to the specified qualities.

Table 302.9.3.(f) Asphalt Pavement Mixture Stability

Property	Value
Density (%)	96 ±1
Stability (%) Hveem Stabilometer	Unless otherwise shown on the plans, Not less than 40 applied on arterials with truck traffic, and Not less than 35 for residential applications

302.9.4. Equipment. All equipment necessary for the construction of the hot-mix asphalt pavement shall be on the project and shall be approved by the OWNER as to condition before the CONTRACTOR shall be permitted to begin construction operations on which the equipment is to be used. All equipment shall be maintained in good repair and operating condition.

302.9.4.1. Bins. Bin storage shall be provided with tight cut-off gates to prevent leakage of aggregates or mineral filler into the weight box. The weight box for aggregates shall be of sufficient capacity to hold a complete batch of aggregates and mineral filler without wasting or leveling and shall be so designed that it shall quickly discharge the entire batch into the mixer. The weight box shall be provided with a close fitting and quick operating cut-off gate so that there shall be no leakage of the aggregates into the mixer and shall be satisfactorily attached to the batching scales.

302.9.4.2. Scales. Scales used for weighing different grades of mineral aggregates may be either the springless dial type or the multi-beam type. All scales must be a tare beam for balancing. The beam scales must also be equipped with a telltale indicator of the springless dial type indicating over-and-under loads of at least 50-pounds. Scales shall be accurate within 4-pounds-per-1000-pounds. If plant vibration interferes with accurate weighing, the scales shall be insulated against shock or vibration.

302.9.4.3. Material Bucket. The asphaltic material bucket shall be of sufficient size to hold the necessary asphaltic material for one batch. If the material is measured by weight, the bucket shall be properly attached to the scales herein specified. If the proportioning is by volume based on weight, the measuring bucket used shall be of the overflow type and shall meet the requirements of the OWNER.

302.9.4.4. Asphalt Storage. Asphalt storage shall be sufficient to meet the requirements of the plant. Asphalt in storage shall be heated by steam coils, absolutely tight to prevent leakage of moisture into the asphalt; the steam for heating shall not be at a temperature in excess of 400°F; direct fire heating of the asphalt shall not be permitted. Agitating asphalt with steam or air shall not be permitted.

302.9.4.5. Steam Heating Systems. The steam heating system shall insure the maintaining of the asphalt at a uniform draw-off temperature at the asphalt bucket of between 275°F and 375°F. The temperature shall be maintained with an efficient positive control of heat at all times as directed or approved by the OWNER. Asphalt heated beyond 375°F either before or during mixing with the mineral aggregate shall be rejected. The draw-off at the asphalt bucket shall be of a quick cut-off type which shall not leak. The asphalt supply line shall be of circulating type, and equipped with a recording thermometer indicating the temperature of the asphalt at the draw-off valve. This thermometer may be combined with the one used in recording the temperature of the aggregate.

302.9.4.6. Weight Bucket. The asphalt weight bucket shall be of an approved type. The scales of weighing the asphalt shall be either the springless dial type or the multi-beam type. The dial type shall be arranged for rapid adjustment at zero and shall be provided with a pointer to indicate the weight of the asphalt required in one batch. The beam type shall have a tare beam for balancing and shall be equipped with a telltale indicator of the springless dial type. If plant vibration interferes with accurate weighing, the scales shall be insulated against shock or vibration. The asphalt shall be sprayed into the mixer through an approved spray bar that shall distribute the asphalt uniformly throughout the length of the mixer.

302.9.4.7. Mixer. The mixer shall be of the pugmill type and shall have a capacity of not less than 1,000-pounds in a single batch. The number of blades and their positions shall give a uniform and complete circulation of the batch. A mixer that segregates mineral aggregate or fails to secure a thorough and uniform mixing with the asphalt and mineral filler shall not be permitted to be used. The

adequacy of the mixer to produce a successful mix shall be determined by mixing the standard batch for the required time, then dumping the batch, and taking samples from different parts of the batch; the samples shall be tested by the extraction test and shall show that the batch is uniform throughout.

All mixers shall be provided with an automatic time lock on the discharge gates of the mixer and the weigh box; and shall be locked for a period of 45-seconds after all the mineral aggregates have been introduced into the mixer. When discharged, the mixture shall have a temperature of 225°F to 350°F. The dump doors of the mixer shall be tight to the dry mineral aggregate or dust so that there shall be no spilling from the pugmill or drum. In introducing the batch into the mixer, all mineral aggregates shall first be introduced. Aggregates shall be thoroughly mixed for a period of 5- to 10-seconds before the asphalt is added; then the total mixture shall be mixed for the time required to produce a homogeneous mixture, in which all particles of the aggregates are uniformly coated.

302.9.4.8. Spreading and Finishing Machine. The spreading and finishing machine shall be of a type approved by the OWNER and capable of producing a surface that shall meet the requirements of the typical cross section and surface test.

302.9.4.9. Rollers. Rollers shall meet the governing specifications for Item 301.1.2. Rolling of Embankment, Subgrade or Flexible Base. The use of vibratory roller on overlay thickness less than 1.5 inches will not be permitted.

302.9.4.10. Straightedges. The CONTRACTOR shall provide acceptable 16-ft. straightedges for the surface testing. Satisfactory templates shall be provided as required by the OWNER.

302.9.4.11. Vehicles for Transporting Mixture. Asphaltic concrete shall be transported from the plant to the site of the work in tight vehicles with metal bottoms previously cleaned of all foregoing substances. The OWNER may require that the vehicles be suitably insulated, and each load shall be covered with canvas or other suitable material of sufficient size to protect the asphaltic concrete from the weather and to prevent loss of material.

302.9.5. Mixing Plants. Mixing plants may be either the weight-batching plant, the continuous mixing type plant or the drum mixing type plant as hereinafter described. All types of plants shall be equipped with satisfactory conveyors, power units, aggregates handling equipment, hot-aggregates screens and bins and dust collectors.

Temporary storing or holding of the asphaltic mixture by a surge-storage system is permitted during the normal day's operation. Overnight storage shall not be permitted.

302.9.5.1. Weight Batching Plant. The proportioning of the various materials entering into the asphaltic mixture shall be as approved or directed by the OWNER. The OWNER shall have access at all times to all parts of the paving plant. The plant shall be of the batch type provided with separate storage bins and chambers for heating and mixing the materials.

The various sizes of mineral aggregates as received shall be stored or stockpiled separately, and the feeding of all sizes of mineral aggregates to the dryer shall be done by mechanical means that shall give a uniform and continuous feed to each of the sizes incorporated in order to give a control of the temperature and grading of the mineral aggregates.

The drying of the mineral aggregates shall be done in such a manner that the finer particles shall not escape with the furnace gases. If forced draft is used, a dust collector system shall be installed. If natural draft is used, the OWNER may require a dust collector system to prevent loss of the finer particles. The aggregate shall be heated in a suitable apparatus that continuously agitates the aggregate during the heating and in which the temperature can be efficiently and positively controlled so that the aggregates shall not be damaged and the mixture produced shall have a temperature between 225°F and 350°F.

A recording thermometer shall be provided which shall record the temperature of the aggregates as they leave the dryer. The recording thermometer shall be provided with a 24-hour chart and may be so equipped that it shall record both the temperature of the aggregates and the temperature of the asphalt incorporated into the batch. The drying apparatus shall be of sufficient size to dry and heat the amount of aggregates required to maintain the plant in continuous operation.

The screening capacity and size of the bins shall be sufficient to screen and store the amount of aggregates required to properly operate the plant and keep the plant in continuous operation at full capacity. Provisions shall be made to enable inspection forces to have easy and safe access to the proper location on the mixing plant where representative samples may be taken from the hot bins for testing. The aggregates shall be separated into at least four bins when producing Type "B" mixtures and at least three bins when producing Type "D" mixtures. If mineral filler is needed, an additional bin shall be provided. These bins shall contain the sizes of aggregates as shown in Table 302.9.3.(a) Dense Graded Hot Mix Master Grading.

302.9.5.2. Continuous Mixing Plant. Cold-aggregates bin and proportioning devices, dryer, and screening and proportioning shall conform to the requirements hereinabove for the weight-batching type of plant. The hot-aggregates proportioning device shall be so designed that when properly operated, a uniform and continuous flow of aggregates into the mixer shall be maintained.

An accurate asphaltic material meter shall be installed in the asphalt line leading to the spray bar, so that the amount of asphalt being used can be accurately determined. The asphaltic material spray bar shall be so designed that the asphalt shall be uniformly and continuously sprayed into the mixture.

The mixer shall be of the pugmill continuous type and shall have a capacity of not less than 40-tons-per-hour of mixture. Any mixer that segregates the aggregates or fails to secure a through and uniform mixing of the aggregates or fails to secure a thorough and uniform mixing of the aggregates with the asphaltic material shall not be used. This shall be determined by taking samples from different parts of a truckload and testing by the extraction test. These tests must show that the load is uniform throughout.

The amount of aggregates and asphaltic material entering the mixer and the rate of travel through the mixer shall be so coordinated that a uniform mixture of the specified grading and asphalt content shall be produced. The mixture shall not vary from the specified mixture by more than the specified tolerances.

The asphaltic mixture shall be at a temperature of between 225°F and 350°F when dumped from the mixer. The OWNER shall determine the lowest temperature, within the above limitations, at which the material can be satisfactorily dried, mixed, transported, spread and compacted, and the mixture furnished by the CONTRACTOR shall be between this determined temperature and 30°F higher.

302.9.5.3. Drum Mixing Plant. The plant shall be adequately designed and constructed for the process of mixing aggregates and asphalt in the drum mixer. The plant shall be equipped with satisfactory conveyors, power units, aggregates-handling equipment, and feed controls and shall consist of the following essential pieces of equipment.

The number of compartments in the cold-aggregates bin shall be equal to or greater than the number of stockpiles of individual materials to be used. The bin shall be of sufficient size to store the amount of aggregates required to keep the plant in continuous operation and of proper design to prevent overflow of material from one compartment to another. The feed system shall provide a uniform and continuous flow of aggregates in the desired proportion to the drum mixer.

A surge-storage system shall be required. It shall be adequate to minimize the production interruptions during the normal day's operations and shall be constructed to minimize segregation. A device such as gob hopper or other similar device approved by the OWNER to prevent segregation in the surge-storage bin shall be required.

The system shall provide positive weight measurement of the combined cold-aggregates feed by use of belt scales or other approved devices. Provisions of a permanent nature shall be made for checking the accuracy of the measuring device as required by Item 302.9.4. Equipment. When a belt scale is used, mixture production shall be maintained so that the scale normally operates between 50-percent and 100-percent of its rated capacity. Belt scale operation below 50-percent of the rated capacity may be allowed by the OWNER if accuracy checks show the scale to meet the requirements of Item 302.9.4. Equipment at the selected rate, and it can be satisfactorily demonstrated to the OWNER that the mixture uniformity and quality have not been adversely affected.

An asphaltic material measuring device meeting the requirements of Item 302.9.4. Equipment shall be placed in the asphalt line leading to the drum mixer so that the cumulative amount of asphalt used can be accurately determined. Provisions of a permanent nature shall be made for checking the accuracy of measuring device output. The asphalt measuring device and line to the measuring device shall be protected with a jacket of hot oil or other approved means to maintain the temperature of the line and measuring device near the temperature specified for the asphaltic material. Unless otherwise shown on the plans, the temperature of the asphaltic material entering the measuring device shall be maintained at ±10°F of the temperature at which the asphalt measuring device was calibrated and set.

The asphaltic material feed-control shall be coupled with the total aggregate weight measuring device in such manner as to automatically vary the asphalt-feed rate as required to maintain the required proportion. A scalping screen shall be required, unless otherwise shown on the plans, and shall be located ahead of any weighing device.

The asphaltic mixture shall be at a temperature of between 225°F and 350°F when dumped from the mixer. The OWNER shall determine the lowest temperature, within the above limitations, at which the material can be satisfactorily dried, mixed, transported, spread and compacted, and the mixture furnished by the CONTRACTOR shall be between this lowest determined temperature and 30°F higher. The drum mix system shall be of the type that continually agitates the aggregates and asphalt mixture during heating and in which the temperature can be so controlled that aggregates and asphalt shall not be damaged in the necessary drying and heating operations required to obtain a mixture of the specified temperature. A continuously recording thermometer shall be provided which shall indicate the temperature of the mixture as it leaves the drum mixer.

Scales may be standard platform truck scales, belt scales or other equipment such as weigh hopper (suspended) scales approved by the OWNER. All scales shall conform to Item 302.9.4. Equipment. If truck scales are used, they shall be placed at a location approved by the OWNER. If other weighing equipment is used, the OWNER may require weight checks by truck scales for the basis of approval of the equipment.

302.9.5.4. Special Instructions for Cellulose Fiber. A separate dry storage area or silo shall be required for cellulose fiber. All equipment used in the storage and handling of cellulose fibers shall be kept a clean condition at all times and shall be operated in such a manner that there will be no contamination with foreign matter.

Cellulose fibers shall be added at 0.3% ±0.1% by mass of the mixture. Drainage shall be tested according to Tex-235-F Determination of Draindown Characteristics in Bituminous Materials. Draindown shall not exceed 0.3%-per-hour.

The cellulose fiber feed system shall supply the proper amount of cellulose fiber to the weigh box. Feeding of the cellulose fiber shall be performed in a manner such that the fibers are not damaged during the feeding and mixing processes and in a manner such that a uniform and constant flow of materials in the required proportions is maintained. The cellulose fiber storage capacity shall be ample to meet the requirements of the plant. Cellulose fiber shall not be allowed in the hot bins.

Mixing system shall control temperature so that the cellulose fiber will not be damaged in drying, heating and mixing operations.

302.9.5.4.1. Weight Batching Plant. Cellulose fiber shall be introduced into the pugmill during the dry mixing of the aggregates, prior to injection of the asphalt.

In introducing the batch into the mixer, all aggregates and then all cellulose fiber shall be introduced first and shall be mixed thoroughly for a minimum period of 5-seconds to uniformly distribute the various sizes of the aggregate and cellulose fiber throughout the batch before asphaltic material is added. The asphaltic material shall then be added and the mixing continued for a wet mixing period of not less than 15-seconds. The mixing period shall be increased if, in the opinion of the Engineer, the mixture is not uniform or the aggregates are not properly coated.

302.9.5.4.2. Continuous Mixing Plant. The mixing requirements shall be the same as is required for a standard Weigh-Batch Plant.

302.9.5.4.3. Drum-Mix Plant. Cellulose fiber shall be added to the mixture during the dry mixing process, unless otherwise approved by the Engineer. Cellulose fiber shall be uniformly dispersed in the mixture. Engineer may require that fiber be introduced into the drum dryer at the recycle port by use of a vane feeder.

The amount of aggregate, cellulose fiber and asphaltic material entering the mixer and the rate of travel through the mixing unit shall be so coordinated that a uniform mixture of the specified grading, cellulose fiber content and asphalt content is produced.

302.9.6. Construction Methods. Asphalt materials shall be handled in accordance with Item 302.5. Storage, Heating and Application Temperature of Bituminous Materials.

The prime coat, tack coat or the asphaltic mixture shall not be placed when the air temperature is below 50°F and is falling but may be placed when the air temperature is above 40°F and is rising, the temperature being taken in the shade and away from artificial heat; with the provision that the asphaltic mixture shall be placed only when the humidity, general weather conditions and temperature and moisture condition of the base, in the opinion of the OWNER, are suitable. Mat thickness of 2 inches and less shall not be placed when the temperature of the surface on which the mat is to be placed is below 50°F.

302.9.6.1. Prime Coat. If required, a prime coat shall be applied to the completed subgrade, subbase or base, in accordance with Item 302.7. Prime Coat. The type and grade of asphaltic material and the application rate shall be as shown on the plans or as directed by the OWNER.

302.9.6.2. Tack Coat. A tack coat shall be applied when the surface to be paved is Portland cement concrete, brick or asphaltic pavement. When a tack coat is required, it shall consist of an application of the asphaltic material indicated and shall be at the rate specified on the plans or as directed by the OWNER, but not to exceed 0.10 gallons-per-square-yard of surface area. The surfaces of curbs, gutters, vertical faces of existing pavements and all structures in actual contact with asphaltic mixes shall be painted with a thin, complete coating of asphaltic material to provide a closely bonded, watertight joint.

302.9.6.3. Compacted Thickness of Hot-Mix Asphalt Pavement Surface Courses and Base Courses.

302.9.6.3.1. Base Courses. The compacted thickness or depth of each base course shall be as shown on the plans. Where the plans require a depth or thickness of the course greater than 4-in., same shall be accomplished by constructing multiple lifts of approximately equal depth, each of which shall not exceed 4-in. compacted depth. If, in the opinion of the OWNER, an additional tack coat is considered necessary between any of the multiple lifts, it shall be applied as in Item 302.9.6.2. Tack Coat and at the rate as directed.

302.9.6.3.2. Surface Courses. The compacted thickness or depth of the asphalt pavement surface course shall be as shown on the plans. Where the plans require a depth or thickness of the surface course greater than 2-in. compacted depth, same shall be placed in multiple courses of equal depth, each of which shall not exceed 2-in. compacted depth. If, in the opinion of the OWNER, an additional tack coat is considered necessary between any of the multiple courses, it shall be applied as in Item 302.9.6.2. Tack Coat and at the rate as directed.

302.9.6.4. Transporting Hot-Mix Asphalt Pavement Material. The mixture shall be hauled to the job site in tight vehicles previously cleaned of all foreign material. The dispatching of vehicles shall be arranged so that all material delivered shall be placed and all rolling shall be completed during daylight hours. In cool weather, or for long hauls, canvas covers may be required. The inside of the truck body may be given a light coating of an approved release agent, if necessary, to prevent the mixture from adhering to the body.

302.9.6.5. Temperature. The hot-mix asphalt mixture shall be at a temperature between 275° and 350°F when dumped from the mixer. The OWNER shall determine the temperature, within the above limitations. The mixture when dumped from the mixer shall not vary from this selected temperature more than 30°F. Restrictions on maximum mixture temperatures placed by environmental regulatory agencies supersede the maximum temperature listed above.

302.9.6.6. Placing. The hot-mix asphalt mixture shall be placed on the approved base course with the specified spreading and finishing machine in such manner that, when properly compacted, the finished course shall comply with the maximum thickness requirements, be smooth and of uniform density, and meet the requirements of the typical cross sections and the surface test. During the placing and spreading of the hot-mix asphalt material, care shall be taken to prevent the spilling of the material onto adjacent pavement, gutters or structures.

302.9.6.7. Compaction. Rolling with a tandem or vibratory roller shall start longitudinally at the sides and proceed toward the center of the surface course, overlapping on successive trips by at least half the width of the rear wheels. Alternate trips of the roller shall be slightly different in length. Rolling with the pneumatic tire roller shall be done as directed by the OWNER. Rolling shall continue until no further compression can be obtained and all roller marks are eliminated. The motion of the rollers shall be slow enough at all times to avoid displacement of the asphaltic surface material. If displacement should occur, it shall be corrected at once by the use of rakes and fresh asphaltic mixtures where required. The roller shall not be allowed to stand on the surface course when it has not been fully compacted and allowed to cool. To prevent adhesion of the surface course to the roller, the wheels shall be kept thoroughly moistened with water, but an excess of water shall not be permitted. All rollers must be in good mechanical condition. All necessary precautions shall be taken to prevent the dripping of gasoline, oil, grease or other foreign matter on the surface course while the rollers are in motion or when standing. In areas where the surface course cannot be compacted with the rollers, hand tamps, lightly oiled, shall be used to secure the required compaction.

Each course, after final compaction, shall have a relative density of not less than 92-percent. The relative density will be determined using Tex-207-F Determining Density of Compacted Bituminous Mixtures and Tex-227-F Theoretical Maximum Specific Gravity of Bituminous Mixtures.

302.9.6.8. Surface Tests. The finished surface of the pavement after compression shall be smooth and true to the established line, grade and cross section. When tested with a 16-ft. straightedge placed parallel to the centerline of the roadway, the finished surface shall have no deviation in excess of $^{1}/_{16}$-in-per-foot from the nearest point of contact. The maximum ordinate measured from the face of the straightedge shall not exceed ¼-in. at any point. Any point in the pavement surface not meeting these requirements shall be immediately corrected.

302.9.6.9. Pavement Thickness Test. Upon completion of the work and before final acceptance and final payment shall be made, pavement thickness test shall be made by the OWNER or its authorized representative unless otherwise specified in the special provisions or in the plans. The number and location of tests shall be at the discretion of the OWNER. The cost for the initial pavement thickness test shall be at the expense of the OWNER. In the event a deficiency in thickness of pavement is revealed during normal testing operations, subsequent tests necessary to isolate the deficiency shall be at the CONTRACTOR'S expense. The cost for the additional coring test shall be at the same rate charged by commercial laboratories.

302.10. MEASUREMENT AND PAYMENT

Prime coat and tack coat shall not be measured for direct payment but shall be considered as subsidiary work pertaining to the placing of hot-mix asphalt mixtures of the type specified.

Hot-mix asphalt pavement material shall be measured complete in place by the ton (2,000-lb.) computed at 110-lb. per S.Y. surface area per inch thickness of course, or by the S.Y. of the type(s) and grade(s) used in the completed and accepted work. Weight shall be determined by a certified scale approved by the OWNER and recorded on serially numbered weight tickets, identifying the vehicle and presented to the OWNER'S representative on the job. Work performed and materials furnished as prescribed by this Item and measured as specified in this Item shall be paid for at the contract unit price bid for the type or types of courses and mixtures as shown in the proposal, which price shall be payment in full for quarrying, furnishing all materials, heating, mixing, hauling, cleaning existing base course or pavement, placing asphaltic mixtures, rolling and finishing, and all labor, tools, equipment and incidentals necessary to complete the work, including the work and materials involved in the application of prime coat and tack coat.

ITEM 303. PORTLAND CEMENT CONCRETE PAVEMENT

303.1. DESCRIPTION

This item shall consist of finished pavement constructed of Portland cement concrete on the prepared subgrade or other base course, in conformity with the plans, as herein specified and as supplemented and/or amended by special provisions and to the lines and grades as established by the OWNER. Concrete shall be considered of satisfactory quality, provided it is:

(1) Made of materials acceptable to the job and meeting the requirements of Item 303.2. Portland Cement Concrete Pavement Materials and special provisions and amendments thereto;
(2) In the proportions approved by the OWNER; and
(3) Mixed, placed, finished and cured in accordance with the requirements of these specifications and any special provisions.
(4) No concrete shall be placed where the temperature of the mix exceeds 95 degrees Fahrenheit or where the time from being batched to placed exceeds the times shown in Table 303.5.5.(a) Concrete Placement.
(5) All concrete utilized for street, alley, drive approach and sidewalk pavement shall be batch mixed unless another method is specifically approved by the OWNER.

303.2. PORTLAND CEMENT CONCRETE PAVEMENT MATERIALS

303.2.1. Aggregates for Portland Cement Concrete Pavement.

303.2.1.1. General Requirements. Aggregates for Portland cement concrete shall conform to the requirements contained in this Item and shall be approved by the OWNER prior to use. Aggregates shall be of such character that it shall be possible to produce workable concrete within the limits contained in this specification.

303.2.1.1.1. Storage. The manner of handling and storage of aggregates shall be such as to prevent intrusion of foreign materials and segregation of sizes. If materials are stored on the ground, the stockpile sites shall be grubbed, cleaned of all vegetation and leveled. In this case, the bottom six-in. layer of aggregate shall not be disturbed and shall not be used in the work.

Where two or more sizes or types of aggregates are delivered to the job, each size or type shall be stored separately.

Aggregates shall be stockpiled on the job or at a central batching plant for a minimum of 24-hours prior to use in the project. At the plant, the aggregate shall be wetted to a uniform moisture content of not less than three-percent below saturated surface dry condition before or while being loaded for shipment. Care shall be exercised to maintain this uniformity of moisture until the aggregates are used in the mix. Wetting of stockpiles to maintain the required percent moisture shall be performed at least 12-hours prior to use.

At the time of use, the aggregates shall be free from frozen material and foreign matter. All grass, wood, sticks, burlap, paper or other material which may have become mixed with the aggregates while stockpiled or in handling shall be removed.

303.2.1.1.2. Aggregate Measuring.

The fine and coarse aggregates shall be measured loose and separately.

By Weight. Aggregate weighing equipment shall conform to the requirements of ASTM C94 Standard Specification for Ready-Mixed Concrete and shall be approved by the OWNER prior to use.

By Volume. The volume measuring equipment shall consist of approved boxes, pans or mechanical devices, which, while in operation, shall give the required volumes of the different kinds of aggregates required for the several classes of concrete. Equipment shall also be so marked and designed that the OWNER can accurately and conveniently check the quantities of each aggregate being used.

Concrete made by continuous mixing shall conform to ASTM C685 Concrete Made by Volumetric Batching and Continuous Mixing.

303.2.1.1.3. Tests. Test of aggregates shall be made in accordance with the applicable current ASTM standards, listed in Table 303.2.1.1.3.(a) Aggregate Tests.

Table 303.2.1.1.3.(a) Aggregate Tests

ASTM Designation	Standard Specification or Standard Test Method (Title)
C29	Bulk Density ("Unit Weight") and Voids in Aggregate
C33	Concrete Aggregates
C40	Organic Impurities in Fine Aggregates for Concrete
C88	Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
C123	Lightweight Particles in Aggregate
C125	Terminology Relating to Concrete and Concrete Aggregates
C127	Density, Relative Density (Specific Gravity) and Absorption of Coarse Aggregate
C128	Density, Relative Density (Specific Gravity) and Absorption of Fine Aggregate
C131	Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
C136	Sieve Analysis of Fine and Coarse Aggregates
C142	Clay Lumps and Friable Particles in Aggregates
C330	Lightweight Aggregates for Structural Concrete
C535	Resistance to Degradation of Large-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
C641	Staining Materials in Lightweight Concrete Aggregates
D8	Terminology Relating to Materials for Roads and Pavements
D75	Sampling Aggregates
D422	Particle-Size Analysis of Soils
D4318	Liquid Limit, Plastic Limit, and Plasticity Index of Soils
D2217	Wet Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants

303.2.1.2. Fine Aggregates. Fine aggregate shall consist of natural sand, manufactured sand or a combination of the two, with or without mineral filler. The sand, or mixture of sand, comprising a single fine aggregate, shall consist of clean, hard, durable, uncoated grains and shall be essentially free from clay lumps.

303.2.1.2.1. Foreign Material and Deleterious Substances. The maximum permissible percentage, by weight, of deleterious substances shall not exceed the amounts in Table 303.2.1.2.1.(a) Deleterious Substances in Fine Aggregates.

The fine aggregate shall be free from an excess amount of salt or alkali and at the time of use shall be free from frozen and/or all foreign material.

Table 303.2.1.2.1.(a) Deleterious Substances in Fine Aggregates

Substance	Maximum % by Weight
Material removed by decantation	3.0%[1]
Other deleterious substances such as coal, shale, coated grains and soft flaky particles	3.0%

1. An additional loss of two-percent by decantation may be allowed, provided this new additional loss is material of the same quality as specified for fine aggregate or mineral filler.

303.2.1.2.2. Gradation. The fine aggregate shall be well graded from fine to coarse and when tested by standard laboratory sieves shall meet the requirements of Table 303.2.1.2.2.(a) Grading Requirements for Fine Aggregates.

Table 303.2.1.2.2.(a) Grading Requirements for Fine Aggregates

Sieve	Percent Passing by Weight
⅜-in. sieve (9.5mm)	100%
No. 4 sieve (4.75mm)	95 to 100%
No. 8 sieve (2.36mm)	80 to 100%
No. 16 sieve (1.18mm)	50 to 85%
No. 30 sieve (600µm)	25 to 65%
No. 50 sieve (300µm)	10 to 30%
No. 100 sieve (150µm)	0 to 10%
No. 200 sieve (75µm)	0 to 3%

303.2.1.2.3. Mineral Filler. Stone dust or crushed sand may be added as a mineral filler, if so directed by the OWNER. Amounts of mineral filler shall not exceed 5-percent of the fine aggregate to improve the workability or quality specified for fine or coarse aggregates. When tested by standard laboratory sieves shall meet the requirements of Table 303.2.1.2.3.(a) Fine Aggregate Mineral Filler.

Table 303.2.1.2.3.(a) Fine Aggregate Mineral Filler

Sieve	Percent Passing
No. 30 sieve (600µm)	95 to 100%
No. 100 sieve (150 µm)	70 to 100%

303.2.1.2.4. Rejection. Fine aggregates which fail to meet the requirements of these specifications may be rejected by the OWNER. Such rejection shall incur no cost to the OWNER.

Fine aggregates sources, from which materials with properties not meeting these specifications are delivered, may be rejected as further supply sources to the project by the OWNER. Such rejection shall incur no cost to the OWNER.

303.2.1.3. Coarse Aggregates. Coarse aggregates shall consist of durable particles of crushed gravel, crushed stone, crushed blast furnace slag meeting the requirements of ASTM C989 (Standard Specification for Ground Granulated Blast-Furnace Slag for Use in Concrete and Mortars) Grade 100 or 120, recycled crushed Portland cement concrete, or a combination of these.

303.2.1.3.1. Foreign Material and Deleterious Substances. The maximum permissible percentage, by weight, of deleterious substances shall not exceed the amounts in Table 303.2.1.3.1.(a) Deleterious Substances in Coarse Aggregates.

Aggregates shall be free from injurious amounts of salt, alkali, vegetable matter, or other objectionable material either free or as an adherent coating. At the time of their use, aggregates shall be free from frozen and/or all foreign material that may have become mixed with them in the stockpile.

Table 303.2.1.3.1.(a) Deleterious Substances in Coarse Aggregates

Substance	Maximum % by Weight
Material removed by decantation	1.0%
Shale, slate or other similar material	1.0%
Clay lumps	0.25%
Soft fragments	3.0%
Other deleterious substances, including friable, thin, elongated or laminated pieces	3.0%
The sum of all deleterious substances, exclusive of material removed by decantation	5.0%

303.2.1.3.2. Gradation. Coarse aggregates shall be well graded in size from coarse to fine. When tested by standard laboratory methods, coarse aggregates shall meet the requirements in Table 303.2.1.3.2.(a) Grading Requirements for Coarse Aggregates for percentage passing each sieve by weight.

Coarse aggregates of different characteristics, though tested and approved, shall not be mixed with other aggregates; but shall be stored, batched and weighed separately.

The difference in percent passing between two adjacent sieve sizes shall not exceed 20%.

Maximum Size Aggregate. The maximum size aggregate is defined as the clear space between the sides of the smallest square openings through which 95-percent of the weight of the aggregate can be passed. The maximum size of aggregates for paving concrete shall not exceed 1½-inches, and shall be reduced in size to meet the following conditions:

(1) one-fifth of the least dimension between forms of that part of the structure in which concrete is to be placed;
(2) three-fourths of the clear space between reinforcement; and
(3) one-third the depth of the slab.

Table 303.2.1.3.2.(a) Grading Requirements for Coarse Aggregates

Size No.	Nominal Size (Sieve with Square Openings)	Amounts Finer than Each Laboratory Sieve (Square-Opening), Mass Percent													
		100 mm (4 in)	90 mm (3½ in.)	75 mm (3 in.)	63 mm (2½ in.)	50 mm (2 in.)	37.5 mm (1½ in.)	25.0 mm (1 in.)	19.0 mm (¾ in.)	12.5 mm (½ in.)	9.5 mm (⅜ in)	4.75 mm (No. 4)	2.36 mm (No. 8)	1.18 mm (No. 16)	0.30 mm (No. 50)
1	90 to 37.5 mm (3½ to 1½ in.)	100	90 to 100	_	25 to 60	_	0 to 15	-	0 to 5	-	-	-	-	-	-
2	63 to 37.5 mm (2½ to 1½ in.)	-	-	100	90 to 100	35 to 70	0 to 15	-	0 to 5	-	-	-	-	-	-
3	50 to 25.0 mm (2 to 1 in.)	-	-	-	100	90 to 100	35 to 70	0 to 15	-	0 to 5	-	-	-	-	-
357	50 to 4.75 mm (2 in to No. 4)	-	-	-	100	95 to 100	-	35 to 70	-	10 to 30	--	0 to 5	-	-	-
4	37.5 to 19.00 mm (1½ to ¾ in.)	-	-	-	-	100	90 to 100	20 to 55	0 to 15	-	0 to 5	-	-	-	-
467	37.5 to 4.75 mm (1½ in to No. 4)	-	-	-	-	100	95 to 100	-	35 to 70	-	10 to 30	0 to 5	-	-	-
5	25.0 to 12.5 mm (1 to ½ mm)	-	-	-	-	-	100	90 to 100	20 to 55	0 to 10	0 to 5	-	-	-	-
56	25.0 to 9.5 mm (1 to ⅜ in.)	-	-	-	-	-	100	90 to 100	40 to 85	10 to 40	0 to 15	0 to 5	-	-	-
57	25.0 to 4.75 (1 to No. 4)	-	-	-	-	-	100	95 to 100	-	25 to 60	-	0 to 10	0 to 5	-	-
6	19.0 to 9.5 mm (¾ to ⅜ in.)		-	-	-	-	-	100	90 to 100	20 to 55	0 to 15	0 to 5	-	-	-
67	19.0 to 4.75 mm (¾ in to No. 4)	-	-	-	-	-	-	100	90 to 100	-	20 to 55	0 to 10	0 to 5	-	-
7	12.5 to 4.75mm (½ in to No. 4)	-	-	-	-	-	-	-	100	90 to 100	40 to 70	0 to 15	0 to 5	-	-
8	9.5 to 2.36 mm (⅜ in to No. 8)	-	-	-	-	-	-	-	-	100	85 to 100	10 to 30	0 to 10	0 to 5	_
89	9.5 to 1.18 mm (⅜ in to No. 16)	-	-	-	-	-	-	-	-	100	90 to 100	20 to 55	5 to 30	0 to 10	0 to 5
9[1]	4.75 to 1.18 mm (No. 4 to No. 16)	-	-	-	-	-	-	-	-	-	100	85 to 100	10 to 40	0 to 10	0 to 5

1. Although size 9 aggregate is defined in ASTM C125 Standard Terminology Relating to Concrete and Concrete Aggregates as a fine aggregate, it is included as a course aggregate when it is combined with a size 8 material to create a size 89, which is a course aggregate as defined by ASTM C125.

303.2.1.3.3. Tests. Results of tests performed according to the applicable standard test methods listed in Table 303.2.1.1.3.(a) Aggregate Tests shall meet the criteria specified by the OWNER. Coarse Aggregates shall have a percent wear of not more than 45 when tested by abrasion and impact in the Los Angeles machine, ASTM C131 and C535.

303.2.1.3.4. Rejection. Coarse aggregates which fail to meet the requirements of these specifications may be rejected by the OWNER. Such rejection shall incur no cost to the OWNER.

Coarse aggregate sources, from which materials with properties not meeting these specifications are delivered, may be rejected as further supply sources to the project by the OWNER. Such rejection shall incur no cost to the OWNER.

303.2.2. Portland Cement. Cement shall be of a standard brand of Portland cement which shall conform to the requirements of ASTM C150 Portland Cement, ASTM C595 Blended Hydraulic Cements, or other applicable test methods of the ASTM and shall be as approved by the OWNER.

303.2.2.1. Delivery. Cement delivered in bags shall be legibly marked on the bag with brand and name of the manufacturer, shall be in good condition at the time of delivery, and shall contain 94-pounds net. Bags of cement varying more than 5-percent from the specified weight may be rejected, and if the average net weight in any shipment, as determined by weighing 50 bags taken at random, is less than 94-pounds, the entire shipment may be rejected. Cement salvaged from discarded or used bags shall not be used.

Cement delivered in bulk may be used, provided the manner and method of handling is approved by the OWNER. When delivered in bulk, the brand name of the manufacturer contained in the shipping information accompanying the shipment shall be furnished to the OWNER prior to the use of the cement. Bulk cement shall be weighed on approved scales.

Cement from different manufacturers, although tested and approved, shall not be mixed, except as approved by the OWNER.

The CONTRACTOR, when required, shall furnish to the OWNER, with each shipment of cement, a statement as the specific surface of the cement expressed in square-centimeters-per-gram.

303.2.2.2. Cement Weighing Equipment. Bulk cement shall be batched by weight. The scales shall be either the beam or springless dial type, of substantial construction with a maximum allowable error of 0.5-percent of the net load and with minimum gradations of not greater than 5-pounds. Provisions shall be made for indicating to the operator that the required load in the weight box or container is being approached, which device shall indicate at least the last 50-pounds of the load. Dial type scales shall be provided with a pointer to the dial.

When a closed-type cement box is used, the cement-weighing scales shall be provided with a springless dial indicator or tare beam to indicate when the weigh box is empty. This indicator for the empty condition of the weigh box shall be in continuous operation. The weigh box shall be fitted with an approved vent and a tightly covered inspection opening of not less than 12-sq.in. The weigh box and scales shall be maintained in a satisfactory condition to meet the requirements for accuracy for weight.

303.2.2.3. Volume and Weight of Bag of Cement. A bag of cement as packed by the manufacturer and weighing 94-pounds shall be considered 1-cubic-foot.

303.2.2.4. Storage. Cement shall be stored in a suitable weathertight building which shall protect the cement from dampness, and placed in such manner that shall permit easy access for proper inspection and identification of each shipment.

303.2.2.5. Rejection. Cement may be rejected for failure to meet any of the requirements of this specification and shall be rejected under the following specific conditions:

(1) any bag of cement which has partially set or which contains any lumps or cakes;
(2) all cement salvaged from torn, discarded or used bags; or
(3) bulk cement which has partially set or which contains any lumps or cakes.

303.2.3. Chemical Admixtures. Unless otherwise provided in the plans or special provisions, approved types of chemical admixtures to minimize segregation, to improve workability or to reduce the amount of mixing water may be used in the rate of dosage specified by the OWNER and in accordance with the manufacturer's recommendations.

Admixtures shall be dispensed in a form by an accurate mechanical dispenser designed for convenient confirmation of the accuracy of measurement. Dispensers shall have sufficient capacity to measure at one time the full quantity required for each batch. Two or more admixtures of different types, such as a water-reducing and air-entraining admixture, may not be compatible when mixed together. Where different admixtures are used, they should be added to the batch separately unless it is known that they can be mixed together satisfactorily. Dosage of admixtures shall not vary from the dosage order by the OWNER by more than 5-percent. In addition:

(1) Chemical admixtures shall conform to ASTM C494 Chemical Admixtures for Concrete, Types "A", "D," "F" and "G" for concrete dosages in accordance with manufacturer's recommendations as specified by the OWNER.

Water-reducing admixtures conforming to ASTM C494, Types "A" and "F", shall be used to improve quality of concrete by obtaining specified strength at lower cement content and to increase slump without increasing water-cement ratio and may also be utilized in improving properties of concrete containing aggregates that are harsh or poorly graded.

Water-reducing, set retarding admixtures, conforming to ASTM C494, Type "D" and "G", may be used during hot weather concrete placement, so as to keep concrete workable during the entire placing period, in order that succeeding placements may be made without development of cold joints or discontinuities in the structural unit.

(2) OWNER'S option: High range water-reducing admixtures, super-plasticizers conforming to ASTM C494, Type "F" and "G", may be used to greatly reduce water content to obtain dense concrete with higher early strengths and maintain high slump or flowing concrete while maintaining low water-cement ratio for concrete that must be placed under difficult conditions such as pump or tremie methods, etc.

(3) Air-entraining admixtures shall conform to ASTM C260 Air-Entraining Admixtures for Concrete.

Dosage shall conform to recommendations of manufacturer, as specified by OWNER, and determined by field testing of concrete mixture by qualified testing personnel in accordance with ASTM C94 Ready-Mixed Concrete.

The CONTRACTOR shall secure the approval of the OWNER for the particular admixture which it proposes to incorporate into the concrete prior to actual use of the admixture. The CONTRACTOR shall furnish such information and evidence that the OWNER may require in its determination of the acceptability of the proposed admixture. When the CONTRACTOR proposes to use an air-entraining admixture which has been previously approved by the OWNER, it shall submit a certification stating that the admixture is the same as that previously approved.

Either prior to or at any time during construction, the OWNER may require that the air-entraining admixture selected by the CONTRACTOR be tested to determine its effect upon the strength of the concrete. When so tested, a 7-day compressive strength of concrete, made with cement and aggregates in proportions to be used in the work and containing the admixture in an amount sufficient to produce from 3- to 6-percent entrained air in the plastic concrete, shall be no less than 85-percent of the strength of concrete, made with the same materials and with the same cement content and consistency but without the admixture.

Any other admixtures for whatever purpose shall have the approval of the OWNER prior to incorporation into the concrete mix.

303.2.4. Mineral Admixtures. Fly ash shall conform to the requirements of ASTM C618 Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete, with the exception that the "Loss on Ignition" requirements shall be a maximum of 3-percent. Fly ash shall be sampled and tested at a frequency schedule in accordance with the requirements of ASTM C311 Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use as a Mineral Admixture in Portland-Cement Concrete. All sources of fly ash for use in Portland cement concrete shall conform to the requirements of Texas Department of Transportation (TxDOT) Material Specification DMS-8900 Fly Ash.

With the approval of the OWNER, fly ash may be used in all classes of concrete to replace a portion of the Portland cement in a mix design. Unless otherwise approved by the OWNER, the maximum cement reduction shall not exceed 25-percent by weight per cubic-yard of concrete. If historical data and general practice in locality of usage substantiates fly ash concrete using higher percentages, CONTRACTOR may submit written request to OWNER for review. Fly ash replacement shall be on a weight basis. The minimum replacement ratio shall be 1.0-pounds of fly ash per 1.0-pounds of cement replaced.

The water-cement ratio of the concrete mix shall be based on total cementitious (cement plus fly ash) materials. Proposed concrete mix designs with materials certification data and laboratory or field mix test results on the properties of the fresh or hardened concrete shall be submitted to the OWNER for approval.

303.2.5. Mineral Filler. Mineral filler shall consist of stone dust, crushed sand or other inert material approved by the OWNER. Mineral filler may be added in amounts not to exceed 10-percent of the weight of

the sand or mixture of sands to improve the workability or plasticity of the concrete mix. Such mineral filler shall be of the quality specified for fine or coarse aggregate, and when tested by laboratory methods shall meet the requirements of Table 303.2.5.(a) Mineral Filler.

Where mineral filler is used, it shall be measured by volume or weighed and batched separately.

Table 303.2.5.(a) Mineral Filler

Sieve	Percent Retained on Sieve
No. 30 sieve (600µm)	0%
No. 200 (75 µm)	0% to 35%

303.2.6. Fibrous Reinforcement. At the OWNER'S option, fibrous reinforcement in concrete may be used unless otherwise shown on the plans or in the contract documents. Fibrous reinforcement shall not be used as a replacement for any reinforcement required for structural purposes.

303.2.6.1. Material. Fibers for reinforcement of concrete shall be in accordance with materials specified in ASTM C1116 Fiber-Reinforced Concrete and Shotcrete.

303.2.6.2. Length and Size. The fibers shall be length and size as specified in ASTM C1116.

303.2.6.3. Testing. Test methods ASTM C995 Time of Flow of Fiber-Reinforced Concrete Through Inverted Slump Cone, and ASTM C1018 Flexural Toughness and First-Crack Strength of Fiber-Reinforced Concrete (Using Beam With Third-Point Loading) in addition to applicable ASTM methods for the testing of concrete shall be used to test the fiber-reinforced concrete. Performance of fiber-reinforced concrete shall meet all requirements as specified in Section 21 of ASTM C1116.

303.2.6.4. Rejection. Fibrous reinforcement or fiber-reinforced concrete may be rejected for failure to meet any of the requirements of this specification or ASTM C1116.

303.2.7. Water. Water for use in concrete shall be reasonably clean and free of oil, acid, alkali, organic matter or other deleterious substances. Water which is suitable for drinking or ordinary household uses may be accepted for use without being tested.

303.2.7.1. Source. Water shall be obtained preferably from a domestic water supply. Where other source of supply is proposed, the approval of the OWNER must be obtained prior to using the water.

303.2.7.2. Measuring Devices. The device for measuring the quantity of water shall indicate the quantity in gallons or pounds and fractions thereof. The operating mechanism shall regulate the quantity required for any given batch within one-percent. The supply inlet shall be cut off automatically when the water is discharged into the mixer.

Upon approval of the OWNER, the water for any one batch in the mixer may be measured in approved cans, buckets or other containers, and no more than the required amount of water shall be introduced into the mixer. The measuring devices shall be checked at the beginning of each job.

303.2.7.3. Tests. If the water is of questionable quality, it shall be tested in accordance with the standard Method of Test of Quality of Water to be used in concrete, AASHTO T26.

303.2.7.4. Rejection. Water for use with cement may be rejected for failure to meet any of the requirements of this specification.

303.2.8. Dowel Bars. Dowel and tie bars shall be either straight or bent, smooth or deformed, as shown on the plans and shall conform to the requirements of Item 303.2.9. Steel Reinforcement. The dowel bars shall be coated with either hot asphalt or an alternate coating, as designated on the plans, to the extent shown on the plans.

303.2.8.1. Dowel Caps. Caps for slip dowel bars shall be of the length shown on the plans and shall have an internal diameter sufficient to permit the cap to freely slip over the bar. In no case shall the internal diameter exceed the bar diameter by more than ⅛-in., and one end of the cap shall be closed. The cap shall be installed to allow the bar to move not less than 1¼-in. in either direction.

303.2.9. Steel Reinforcement. Concrete reinforcement is the metal (rods or fabric) imbedded in concrete in such a manner that the reinforcement and concrete act together in resisting forces.

303.2.9.1. Material. Unless otherwise specified or designated on the plans, the metal for all bar reinforcement shall be one of the following:

303.2.9.1.1. New Billet Steel. New billet steel shall meet the requirements of ASTM A615/A615M Deformed and Plain Billet-Steel Bars for Concrete Reinforcement.

303.2.9.1.2. Axle Steel. Axle steel shall meet the requirements of ASTM A996/A996M Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement.

303.2.9.1.3. Rail Steel. Axle steel shall meet the requirements of ASTM A996/A996M Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement.

The use of rail steel or axle steel shall not be permitted where bending of the bar is required.

Unless otherwise designated on the plans, all reinforcement steel bars shall be deformed in accordance with the requirements of ASTM A615/A615M or A996/A996M, as appropriate. Twisted bars are not considered deformed and shall not be used. The deformed bars shall provide a net sectional area at all points equivalent to that of plain square or round bars of equal nominal size.

Bars for spiral reinforcement shall be plain bars rolled from billets directly reduced from ingots and shall conform to the requirements of ASTM A615/A615M.

303.2.9.2. Sizes and Weights. The size and weight of reinforcing bars shall conform to the requirements of ASTM A615/A615M.

303.2.9.3. Bending. Reinforcement bars shall be bent cold to the shapes indicated on the plans. All bending of hard grade new billet steel shall be done in the shop. Bends shall be true to the shapes indicated, and irregularities shall be cause for rejection. Unless otherwise shown on the plans, bends for stirrups and ties shall be made around a pin having a diameter not less than two times the minimum thickness of the bar. Other bends shall be made according to the latest code of Standard Practice of the Reinforcing Steel Institute.

303.2.9.4. Storage. Reinforcement shall be stored above the ground surface upon skids, platforms or other supports, and shall be protected from mechanical injury and surface deterioration caused by exposure to the conditions producing rust. When placed in the work, the reinforcement shall be free from dirt, loose rust, scale, painting, oil or other foreign material.

303.2.9.5. Rejection. Reinforcement may be rejected for failure to meet any of the requirements of this specification. Additionally, reinforcement may be rejected for the following:

(1) reinforcement exceeding the allowable variations,
(2) reinforcement not bent in accordance with the details,
(3) reinforcement with a coating of dirt, loose scale, paint, oil or other foreign substances which shall prevent bonding of the concrete and reinforcement,
(4) twisted bars, or
(5) reinforcement subjected to construction traffic.

303.2.10. Steel Wire Reinforcement. At the OWNER'S option the use of welded wire fabric may be used in lieu of deformed reinforcement bars unless otherwise shown on the plans or in the contract specifications.

Welded wire fabric shall be delivered to the job site in sheets. Rolls of wire fabric shall not be permitted.

The size of welded wire fabric shall be 12 x 12- W 4 x W 4 with a nominal diameter in inches of 0.225 and a nominal weight 0.136 lbs/linear foot.

303.2.10.1. Material. Wire for fabric reinforcement shall be cold-drawn from rods hot-rolled from billets and shall conform to the requirements of ASTM A82 Steel Wire, Plain, for Concrete Reinforcement. Welded wire fabric shall conform to the requirements of ASTM A185 Steel Welded Wire Reinforcement, Plain, for Concrete.

303.2.10.2. Sizes and Weights. The properties of wire fabric shall conform to the requirements of ASTM A82 or ASTM A185, as appropriate.

303.2.10.3. Storage. Reinforcement shall be stored above the ground surface upon skids, platforms or other supports, and shall be protected from mechanical injury and surface deterioration caused by exposure to the conditions producing rust. When placed in the work, the reinforcement shall be free from dirt, loose rust, scale, paint, oil or other foreign materials.

303.2.10.4. Rejection. Reinforcement may be rejected for failure to meet any of the requirements of this specification, and specifically for the following:

(1) reinforcement exceeding the allowable variations,
(2) reinforcement not bent in accordance with the details,
(3) reinforcement with a coating of dirt, loose scale, paint, oil or other foreign substances which shall prevent bonding of the concrete and reinforcement, or
(4) twisted bars.

303.2.11. Reinforcement Bar Chairs. Reinforcement bar chairs or supports shall be of adequate strength (if specified) to support the reinforcement bars and shall not bend or break under the weight of the reinforcement bars or CONTRACTOR'S personnel walking on the reinforcing bars.

Bar chairs may be made of metal (free of rust), precast mortar or concrete blocks or plastic. Pre-cast mortar or concrete blocks must be approved by the OWNER; and the CONTRACTOR shall supply test data showing the strength of the mortar or concrete blocks.

For approval of plastic chairs, representative samples of the plastic shall show no visible indications of deterioration after immersion in a 5-percent solution of sodium hydroxide for 120-hours.

303.2.11.1. Rejection. Bar chairs may be rejected for failure to meet any of the requirements of this specification.

303.2.12. Joint Filler. Joint filler is the material placed in concrete pavement and concrete structures to allow for the expansion and contraction of the concrete.

303.2.12.1. Material. Expansion joint materials shall consist of boards or a premolded asphalt board tested in accordance with ASTM D545 Test Methods for Preformed Expansion Joint Fillers for Concrete Construction (Nonextruding and Resilient Types).

Boards for expansion joint filler shall be of the required size, shape and type indicated on the plans or required in the specifications. Boards shall be of selected stock of redwood, cypress, gum, southern yellow pine, or Douglas fir timber. The boards shall be sound heartwood and shall be free from sapwood, knots, clustered birdseyes, checks and splits. Occasional sound or hollow birdseyes, when not in clusters, shall be permitted, provided the board is free from any other effects that shall impair its usefulness as a joint filler. With the exception of redwood and cypress, all boards shall be preservative treated according to American Wood-Preservers' Association (AWPA) Standards.

Asphalt boards for expansion joint filler shall be of the required size and uniform thickness and, when used in transverse joints, they shall conform approximately to the shape of the pavement crown shown on the plans and details. Asphalt boards shall consist of two liners of 0.016 asphalt impregnated kraft paper filled with a mastic mixture of asphalt and vegetable fiber and/or mineral filler. Boards shall be smooth, flat and straight throughout, and shall be sufficiently rigid to permit ease of installation. Boards shall be furnished in lengths equal to the width between longitudinal joints, and may be furnished in strips or scored sheet of the required shape.

Asphalt boards, when tested in accordance with the following described methods, shall not deflect from the horizontal more than ¾-inches in 3½-inches. A sample of the board, 2-in. wide and 6-in. long, flat, straight and cut with its length parallel to the lay of the fiber, shall be clamped between two blocks in the direction of its thickness in such manner that 3½-in. length of the sample shall extend unsupported and at right angles from the common plane of the block faces. The samples and clamp so assembled shall be maintained at a temperature of 180°F for 2-hours, with the length and width of the clamped portion of the sample horizontal after which the deflection from the horizontal of the unclamped portion shall be immediately measured.

303.2.12.2. Dimensions. The thickness of the expansion joint filler shall be shown on the plans; the width shall be not less than that shown on the plans, providing for the top seal space.

303.2.12.3. Rejection. Expansion joint filler may be rejected for failure to meet any of the requirements of this specification.

303.2.13. Curing Materials. This specification shall govern the materials to be used in the curing of concrete. The materials when applied as elsewhere specified shall retain the moisture, present in the concrete at the time of application of curing material, within specified limits for the curing period.

303.2.13.1. Material. Materials for the curing of concrete shall conform to the following requirements:

303.2.13.1.1. Membrane-Forming Compounds. The membrane curing compound shall conform to the requirements of ASTM C309 Liquid Membrane-Forming Compounds for Curing Concrete, Type 2, white pigmented compound, unless otherwise specified or indicated. It shall be of such nature that it shall not produce permanent discoloration of concrete surfaces nor react deleteriously with the concrete.

The compound shall produce a firm, continuous uniform moisture-impermeable film free from pinholes and shall adhere satisfactorily to the surfaces of damp concrete. It shall, when applied to the damp concrete surface at the specified rate of coverage, dry to touch in 1-hour and dry through in not more than 4-hours under normal conditions suitable for concrete operations. It shall adhere in a tenacious film without running off or appreciably sagging. It shall not disintegrate, check, peel or crack during the required curing period.

The compound shall not peel or pick up under traffic and shall disappear from the surface of the concrete by gradual disintegration.

The compound shall be delivered to the job site in the manufacturer's original containers only, which shall be clearly labeled with the manufacturer's name, the trade name of the material and a batch number or symbol with which test samples may be correlated.

When tested in accordance with ASTM C156 Water Retention by Concrete Curing Materials, the liquid membrane-forming compound shall restrict the loss of water present in the test specimen at the time of application of the curing compound to not more than 0.01-oz.-per-in^2 of surface.

303.2.13.1.2. Cotton Mats. The cotton mats used for curing shall meet the following requirements:

Each mat shall have a finished width of approximately 5-ft. 6-in.; and after shrinkage shall be at least 6-in. longer than the width of the concrete to be cured.

The mats shall be composed of a single layer of cotton filler, completely enclosed in a cover of cotton cloth. The cotton filler shall be of low-grade cotton, cotton linters of such shall contain not less than ¾-pound of cotton filler per square-yard of mat, uniformly distributed. The cotton cloth used for covering material shall be Osnaburg, weighing not less than 6$^3/_{10}$-ounces-per-square-yard.

All mats shall be stitched longitudinally with continuous parallel rows of stitching at intervals of not more than 4-in. or shall be tufted both transversely and longitudinally at intervals of not more than 3-in. The sewing or tufting shall not be done so tightly that the mat shall not contact the surface of the concrete at all points when saturated with water.

To insure the complete covering of the concrete where the mats fit together, there shall be a flap extending all along one side of each mat. This flap shall be composed of two thicknesses of the cover material and shall be at least 6-in. in width.

303.2.13.1.3. Waterproof Paper. Waterproof paper shall consist of two sheets of plain kraft paper cemented together with a bituminous material in which are imbedded cords or strands of fiber running in both directions of the paper, not more than 1¼-in. apart. The paper shall be light in color; shall be free of visible defects; and shall have a uniform appearance. It shall be sufficiently strong and tough to permit its use under the conditions existing on streets and structural work without tearing or otherwise becoming unfit for the use for which it is intended. The paper shall conform to specifications for ASTM C171 Sheet Materials for Curing Concrete.

When tested in accordance with ASTM C156 Water Retention by Concrete Curing Materials, the paper shall restrict the loss of water present in the test specimen at the time of application of the waterproof paper to not more than 0.055-grams-per-square-centimeter of surface.

303.2.13.1.4. Polyethylene Film. Polyethylene film shall be opaque pigmented white in color; and shall be manufactured from virgin resin without additives or scrap. The film shall have a minimum thickness of 4-mils. The permissible moisture loss from the concrete, when tested in accordance with ASTM C156 Water Retention by Concrete Curing Materials, shall not exceed 0.055-grams-per-square-centimeter of surface. The film shall be sufficiently strong and tough to permit its use under the conditions existing on paving or structural projects without being torn or otherwise rendered unfit

for the use intended during the curing period. It shall be of uniform thickness throughout, free of pinholes and other blemishes.

303.2.13.2. Rejection. Concrete curing materials may be rejected for failure to meet any of the requirements of this specification.

303.2.14. Joint Sealant. Joint sealing compound shall consist of hot poured polymer or ready-mixed cold-applied sealant, silicone joint sealant or other material approved by the OWNER. It shall not crack or break when exposed to low temperatures. The cured sealant must not pick up or "track" at elevated road temperature.

303.2.14.1. Materials.

303.2.14.1.1. Hot Poured Polymer. The joint sealing compound shall melt to the proper consistency for pouring and shall solidify on cooling to atmospheric temperatures. At no time shall the material be heated to temperature exceeding 450°F; any material heated above 450°F shall be rejected.

Hot poured polymer shall be tested in accordance with TxDOT Test Method Tex-525-C Tests for Asphalt and Concrete Joint Sealers and shall meet the requirements in Table 303.2.14.1.1.(a) Hot Poured Polymer Sealant Requirements.

Table 303.2.14.1.1.(a) Hot Poured Polymer Sealant Requirements

Property	Test Parameters	Required Result
Penetration	32°F , 7-oz. , 60-sec.	Minimum 0.1-in.
	77°F , 5-oz., 5-sec.	0.45- to 0.3-in.
Flow	5-hours, 140°F, 75° incline	Maximum 0.2-in.
Bond extension	15°F, 5-cycles	No cracking of the joint sealing material or break in the bond between the joint sealer material and the mortar pieces.

303.2.14.1.2. Ready-Mixed Cold-Applied. This sealant shall be a single component and shall consist of a homogeneous blend of asphalt emulsion, polymer, and inert filler. The material shall be a resilient, adhesive compound capable of effectively sealing properly cleaned joints and cracks in concrete and asphalt pavements against infiltration of moisture throughout repeated cycles of contraction and expansion and which shall not be picked up by vehicle tires, particularly at summer temperatures.

This Item covers an emulsion composed principally of a semi-solid asphalt base, water and emulsifying agent suitable for sealing cracks at ambient temperatures of 40°F and higher. The emulsion shall be modified with a polymer and shall be smooth and homogeneous, with no evidence of polymer separation.

The cold-applied crack sealant shall meet the requirements in Table 303.2.14.1.2.(a) Cold-Applied Sealant Requirements. Material shall be free-flowing down to 40°F, such that routine pavement joints and cracks are filled to a depth of 1½-in. without the addition of heat.

The material shall be furnished in 55-gallon drums.

Table 303.2.14.1.2.(a) Cold-Applied Sealant Requirements

Property	Test Method	Required Result	
		Minimum	Maximum
Viscosity[1], Brookfield, 77°F	ASTM D2196 Rheological Properties of Non-Newtonian Materials by Rotational (Brookfield type) Viscometer; Method A	6,000 Centipoise	25,000 Centipoise
Storage Stability Test, One-Day	AASHTO T59	-	1-Percent
Sieve Test	AASHTO T59	-	0.10-Percent
Evaporations[2] and Tests on Residue			
Residue	See Note 2.	65-Percent	-
Penetration test on Residue, 77°F, 100g, 5-seconds	AASHTO T49	35 (0.1-mm)	75 (0.1-mm)
Softening Point test on Residue, R.&B.	AASHTO T53	140°F	-
Ductility test on Residue, 39.2°F, 5 cm/Min	AASHTO T51	100-cm	-

1. OWNER may require Viscosity Profile in lieu of single-spindle viscosity test, in which case the apparent viscosity shall be 10,000.
2. Residue may be obtained by the following evaporation procedure: Mass 200g of sealant into a 1000-ml beaker or a 1-quart can and place in a heating mantle designed for a 1000-ml beaker. During the evaporation the sealant should be stirred frequently to prevent foam-over or local overheating. The temperature shall be maintained between 260°F and 300°F for 3- to 5-minutes after the material is water free. Pour required specimen.

303.2.14.1.3. Thermoplastic Cold-Applied. If approved by the OWNER, thermoplastic cold-applied jointing material may be used according to manufacturer's recommendations.

303.2.14.2. Rejection. Materials may be rejected for failure to meet any of the requirements of this specification.

303.2.15. Elastomeric Materials. This material shall conform to the requirements of the TxDOT Item 435 Elastomeric Materials. This item shall govern for the materials, testing and fabrication of elastomeric materials, except as otherwise covered in other specifications or on the plans.

303.2.15.1. Rejection. Elastomeric materials may be rejected for failure to meet any of the requirements of this specification.

303.3. MIX DESIGN AND MIXING CONCRETE FOR PAVEMENT

303.3.1. Description. This section shall govern for the concrete in pavements.

303.3.2. Equipment. All machinery and equipment necessary for the prosecution of the work specified herein shall be on the project and shall be approved by the OWNER as to condition before the CONTRACTOR shall be permitted to begin operations on which the machinery or equipment is to be used. All machinery and equipment shall be maintained in good condition to insure the completion of the work without excessive delays for repairs and replacements.

303.3.3. Concrete Mix Design and Control. At least 10-days prior to the start of concrete paving operations, the CONTRACTOR shall submit to the OWNER a design of the concrete mix it proposes to use together with samples, if requested, of all materials to be incorporated into the mix and a full description of the source of supply of each material component. The proposed batch designs must be submitted to the OWNER on the approved form.

The design of the concrete mix shall produce a quality concrete complying with these specifications and meet the requirements of ACI 318 (most recent edition) - PART 3 Construction Requirements, CHAPTER 5, Concrete Quality, except as amended by these provisions. The concrete mix design shall include the following information:

(1) Design Requirements and Design Summary
(2) Material source
(3) Dry weight of cement/cu. yd. and type
(4) Dry weight of fly ash/cu. yd. and type, if used
(5) Saturated surface dry weight of fine and coarse aggregates/cu. yd.
(6) Design water/cu. yd.
(7) Quantities, type, and name of admixtures with manufacturer's data sheets
(8) Current strength tests or strength tests in accordance with ACI 318
(9) Current Sieve Analysis and -200 Decantation of fine and coarse aggregates and date of tests
(10) Fineness modulus of fine aggregate
(11) Specific Gravity and Absorption Values of fine and coarse aggregates
(12) L.A. Abrasion of coarse aggregates

All material samples submitted to the OWNER shall be sufficiently large to permit laboratory batching for the construction of test specimens to check the adequacy of the design. When the OWNER has approved the design mix, there shall be no change or deviation from the proportions thereof or sources of supply except as hereinafter provided. No concrete may be placed on the job site until the mix design has been approved by the OWNER in writing to the CONTRACTOR.

303.3.4. Quality of Concrete.

303.3.4.1. Consistency. In general, the consistency of concrete mixtures shall be such that:

(1) the mortar shall cling to the coarse aggregate,
(2) the aggregate shall not segregate in concrete when it is transported to the place of deposit,
(3) the concrete, when dropped directly from the discharge chute of the mixer, shall flatten out at the center of the pile, but the edges of the pile shall stand and not flow,
(4) the concrete and mortar shall show no free water when removed from the mixer,
(5) the concrete shall slide and not flow into place when transported in metal chutes at an angle of 30° with the horizontal,
(6) the surface of the finished concrete shall be free from a surface film or laitance, and
(7) the concrete shall be uniform and workable.

The consistency of the concrete as placed should allow the completion of all finishing operations without the addition of water to the surface. When field conditions are such that additional moisture is needed for the final concrete surface finishing operation, the required water shall be applied to the surface by fog spray only; and shall be held to a minimum amount. The concrete shall be workable, cohesive, possess satisfactory finishing qualities and be of the stiffest consistency that can be placed and vibrated into a homogeneous mass. Excessive bleeding shall be avoided.

If the strength or consistency required for the class of concrete being produced is not secured with the minimum cement specified or without exceeding the maximum water/cement ratio, the CONTRACTOR may use, or the OWNER may require, an approved cement dispersing agent (water reducer); or the CONTRACTOR shall furnish additional aggregates, or aggregates with different characteristics, or the CONTRACTOR may use additional cement in order to produce the required results. The additional cement may be permitted as a temporary measure, until aggregates are changed and designs checked with the different aggregates or cement dispersing agent.

The CONTRACTOR is solely responsible for the quality of the concrete produced. The OWNER reserves the right to independently verify the quality of the concrete through inspection of the batch plant, testing of the various materials used in the concrete and by casting and testing concrete cylinders or beams on the concrete actually incorporated in the pavement.

303.3.4.2. Standard Classes. Unless otherwise shown on the plans or detailed specifications, the Standard Classes of Pavement Concrete shown in Table 303.3.4.2.(a) shall be used.

Streets, alleys, driveways, and inlets shall be constructed in accordance with these specifications using the classes of concrete, machine or hand finished, whichever is appropriate. Mass pour medians, noses, and islands shall use hand-finished concrete.

The testing does not in any way change the penalties imposed on the CONTRACTOR for deficient strength outlined elsewhere in these specifications.

Table 303.3.4.2.(a) Standard Classes of Pavement Concrete.

Class of Concrete[1]	Minimum Cementitious Lb./CY	28 Day Min. Compressive Strength[2] psi	28 Day Min. Beam Strength[2,3] psi	Maximum Water/ Cementitious Ratio	Coarse Aggregate Maximum Size[4]
A[5]	470	3000	500	0.58	1½"
C	564	3600	600	0.53	1½"
P1[6]	517	4000	N/A	0.49	1½"
P2[7]	564	4500	N/A	0.45	1½"
M	As directed by the OWNER or as shown on the plans				

1. All exposed horizontal concrete shall have entrained – air.
2. Minimum Strength Required by OWNER [Compressive or Flexural]
3. ASTM C78 (Third-Point); Reduce by 10% when Type II Cement is Used
4. Smaller nominal maximum size aggregate may be used if strength requirement is satisfied
5. Sidewalks, separate curb and gutter, and 4-inch thick median pavement
6. Machine Finished
7. Hand Finished

303.3.4.3. Performance Classes. Performance Classes of structural concrete shall meet the requirements in Table 303.3.4.3.(a) Performance Classes of Pavement Concrete.

Table 303.3.4.3.(a) Performance Classes of Pavement Concrete

Class of Concrete[1]	Minimum Cementitious Lb./CY	28-Day Compressive Strength psi	28-Day Flexural Strength[2,3] psi	Maximum Water/ Cementitious Ratio[4]	Coarse Aggregate Maximum Size[5]
PA	423	3000[6]	425	0.58	1½"
PC	517	3600[6]	510	0.53	1½"
PP1[7]	517	4000	N/A	0.48	1½"
PP2[8]	564	4500	N/A	0.44	1½"
PM	As directed by the OWNER or as shown on the plans				

1. All exposed horizontal concrete shall have entrained – air.
2. ASTM C78 (Third-Point); Reduce by 10% when Type II Cement is used
3. For early form removal
4. Consistent with ACI 211.1 Table 6.3.4(a) Relationship between water-cementitious materials ratio and compressive strength of concrete
5. Smaller nominal maximum size aggregate may be used if Strength requirement is satisfied
6. Calculated Average Required Compressive Strength Considering ACI 318 - Sec. 5.3.2.1 shall be strength shown times 1.15
7. Machine Finish
8. Hand Finish

303.3.4.4. Slump. Slump requirements for pavement and related concrete shall be as specified in Table 303.3.4.4.(a) Pavement Concrete Slump Requirements. No concrete shall be permitted with slump in excess of the maximums shown. Any concrete mix failing to meet the above consistency requirements, although meeting the slump requirements, shall be considered unsatisfactory, and the mix shall be changed to correct such unsatisfactory conditions.

Table 303.3.4.4.(a) Structural Concrete Slump Requirements.

Concrete Use	Avg. Slump (in.)	Max. Slump (in.)
Slip Form Paving	3	4
Hand formed paving	4	5
Sidewalk, Separate Curb and Gutter, and Other Miscellaneous Concrete	As specified by OWNER	

303.3.5. Mixing and Delivery. The concrete shall be produced in an approved method conforming to the requirements of this specification and ASTM C94/C94M Standard Specification for Ready-Mixed Concrete or National Ready-mixed Concrete Association (NRMCA). Ready-mix concrete shall be permitted in lieu of the paver-mixer. When ready-mix concrete is used, sampling provisions of ASTM C94 Alternate Procedure 2 shall govern. If fiber-reinforced concrete is used, mixing shall be in accordance with ASTM C1116 Fiber-Reinforced Concrete and Shotcrete. All materials for concrete placed in pavements shall conform to the requirements of the governing item of this specification.

303.3.5.1. Batch Mixing. The concrete shall be mixed in a batch mixer and only in such quantities as are required for immediate use. The mixing of each batch, after all materials are in the drum, shall continue until it produces a thoroughly mixed concrete of uniform mass as determined by established mixer performance ratings and inspection, or appropriate uniformity tests as described in ASTM C94. The entire contents of the drum shall be discharged before any materials are placed therein for the succeeding batch. Retempering or remixing shall not be permitted.

303.3.5.1.1. Mixer. The mixer shall produce concrete of uniform consistency and appearance.

303.3.5.1.2. Cleaning. The mixer shall be cleaned thoroughly each time when out of operation for more than 30 minutes.

303.3.5.2. Transit Mixing. When transit mixing is used, the transit mixer shall be of an approved revolving drum or revolving blade type so constructed as to produce a thoroughly mixed concrete with a uniform distribution of the materials throughout the mass and shall be equipped with a discharge mechanism which shall insure the discharging of the mixed concrete without segregation.

303.3.5.2.1. Prevention of Leaking. The mixer drum shall be watertight when closed and shall be equipped with a locking device that shall automatically prevent the discharging of the mixer prior to receiving the required number of revolutions.

303.3.5.2.2. Mixing. The entire quantity of mixing water shall be accurately measured by a visible calibrated mechanism. Leaking water valves shall be considered as ample reason for condemnation of the mixer unit and removal from the job by the OWNER. Each batch shall be mixed not less than 70 nor more than 100 revolutions at the rate of rotation specified by the manufacturer as mixing speed. Any additional mixing shall be done at a slower speed specified by the manufacturer for agitation and shall be continuous until the batch is discharged.

303.3.5.2.3. Counters. Truck mixers shall be equipped with actuated counters by which the numbers of revolutions of the drum may be readily verified. The counters shall be actuated at the time of starting mixing at mixing speeds.

303.3.5.2.4. Delivery. The rate of delivery of the mixed concrete shall be such that the interval between loads shall not exceed 10-minutes. The concrete shall be delivered to the site of the work and discharged from the mixer before the drum has been revolved 300 revolutions, after the introduction of the mixing water with the dry materials.

303.3.5.3. Central Mixing Plant. A central mixing plant shall be allowed, provided the method of mixing and handling has first been approved by the OWNER.

303.3.5.4. Commercial Concrete Plants. In the event the CONTRACTOR elects to use concrete produced by a commercial concrete plant, an agreement shall be drawn and executed by the responsible executive management of said plant granting the OWNER ingress and egress to all parts of the plant with full authority to make any and all required tests of aggregates and to regulate and control

all batching plant and/or central mixing plant operations. This regulatory control shall be applicable only to the concrete produced by the commercial plant for the payment herein specified.

303.3.5.5. Delivery Tickets. For transit mix operations, the manufacturer of the concrete shall, before unloading, furnish to the purchaser with each batch of concrete at the site a delivery ticket on which is printed, stamped, or written, the following information to determine that the concrete was proportioned in accordance with the approved mix design:

(1) Name of concrete supplier
(2) Serial number of ticket
(3) Date
(4) Truck number
(5) Name of purchaser
(6) Specific designation of job (name and location)
(7) Specific class, design identification and designation of the concrete in conformance with that employed in job specifications
(8) Amount of concrete in cubic yards (or cubic meters)
(9) Time loaded or of first mixing of cement and aggregates
(10) Water added by receiver of concrete and his/her initials
(11) Weight of cement
(12) Weight of fly ash
(13) Type and amount of admixtures
(14) Information necessary to calculate the total mixing water added by the producer (total mixing water includes free water on the aggregates, water and ice batched at the plant, and water added by the truck operator from the mixer tank);
(15) Maximum size of aggregate
(16) Weights of fine and coarse aggregate

For on-site concrete plant operations, the CONTRACTOR shall supply to the OWNER a batch ticket with the following information and for each continuous paving operation, provide receipts and invoices to substantiate the amounts of cement and fly ash used in the placement.

(1) At the beginning of each day's placement, a list of the actual batch weights to be used shall be given to the OWNER.
(2) When any changes are made, a new list of weights shall be given to the OWNER.

303.4. EQUIPMENT

303.4.1. General. All equipment necessary for the construction of this item shall be on the project and shall be approved by the OWNER as to condition before the CONTRACTOR shall be permitted to begin construction operations on which the equipment is to be used.

303.4.2. Field Laboratory. A field laboratory structure shall be required only when specifically required and provided for in the special provisions.

303.4.3. Slip Form Paver. Slip form paving equipment shall be provided with traveling side forms of sufficient dimensions, shape and strength so as to support the concrete laterally for a sufficient length of time during placement to produce pavement of the required cross section. The equipment shall spread, consolidate, screed and float-finish the freshly placed concrete in such a manner as to provide a dense and homogeneous pavement.

303.4.4. Forms. The side forms shall be metal, of approved cross section and bracing, of a height not less than the prescribed edge thickness of the concrete section, and a minimum of 10-ft. in length for each individual form. Forms shall be of ample strength and shall be provided with adequate devices for secure setting so that when in place they shall withstand the impact and vibration of equipment imposed thereupon without appreciable springing or settlement. In no case shall the base width be less than 8-in. for a form 8-in. or more in height. The forms shall be free from warps, bends or kinks and shall show no variation from the true plane for face or top. Each 10-ft. length of forms shall be provided with at least 3 pins for securely staking in position. Sufficient forms shall be provided for satisfactory prosecution of the work. 10-ft. metal

form sections shall be used in forming curves with a 250-ft., and larger radius. For curves with a radius of less than 250-ft., acceptable flexible metal forms or wood forms may be used upon approval by the OWNER.

303.4.5. Mechanical Vibratory Equipment. All concrete placed for pavement shall be consolidated by approved mechanical vibrators operated ahead of the transverse finishing machine and designed to vibrate the concrete internally and/or from the surface. Unless otherwise shown on the plans, vibrators of the surface-pan type shall be used for full-depth placement. Both types of vibrators shall be furnished and may be used concurrently at the discretion of the OWNER. Vibratory members shall extend across the pavement practically to, but shall not come in contact with, the side forms. Mechanically-operated vibrators shall be mounted in such a manner as not to interfere with the transverse or longitudinal joints.

The internal-type vibrators shall be spaced at not more than 24-in. and shall be equipped with synchronized vibratory units. Separate Vibratory units shall be spaced at sufficiently close intervals to provide uniform vibration and consolidation to the entire width of the pavement. The frequency in air of the internal spud-type Vibratory units shall be not less than 8,000-cycles-per-minute and not less than 5,000-cycles-per-minute for tube types. The method of operation shall be as directed by the OWNER. The CONTRACTOR shall have a satisfactory tachometer available for checking the vibratory elements.

The pavement vibrators shall not be used to level or spread the concrete but shall be used only for purposes of consolidation. The vibrators shall not be operated where the surface of the concrete, as spread, is below the elevation of the finished surface of the pavement, except for the first lift of concrete where the double strike-off method of placement is employed. The vibrators shall not be operated for more than 15-seconds while the machine upon which they are installed is still.

The pan-type vibrator units shall apply the vibrating impulses directly to the surface of the concrete. The operating frequency shall not be less than 3,500-cycles- nor more than 4,200-cycles-per-minute in air. The CONTRACTOR shall have a satisfactory tachometer available for checking the speed of the vibratory elements.

Approved hand manipulated mechanical vibrators shall be furnished in the number required for provision of proper consolidation of the concrete along the forms, at joints and in areas not covered by mechanically controlled vibrators. These vibrators shall be sufficiently rigid to insure control of the operating position of the vibrating head.

Complete and satisfactory consolidation of the concrete pavement is a most important requirement of this specification. Cores taken as required by Item 303.8. Pavement Testing and Evaluation shall be carefully examined for voids, honeycombing or other evidence of incomplete consolidation. If such evidence is present, changes in the consolidation procedures and/or equipment shall be made to insure satisfactory consolidation.

303.4.6. Vibrating Screed. The mechanically vibrated screed shall be provided with a template adjusted to the crown of the concrete section. The template shall be power vibrated, adjustable in height and mounted to ride on the forms. The mechanical vibration of one of the screeds on the transverse finishing machine specified in Item 303.4.7. Transverse Finishing Machine shall be acceptable.

303.4.7. Transverse Finishing Machine. The transverse finishing machine shall be provided with two screeds accurately adjusted to the crown of the pavement, shall be power driven and mounted in a substantial frame equipped to ride on the forms. The machine shall be so designed and operated as to strike off and consolidate the concrete.

Finishing machines shall be maintained in a tight and good operating condition, accurately adjusted to the required crown or profile and free from deflection, wobble or vibration tending to affect the surface finish. Machines failing to meet these requirements shall be rejected by the OWNER, and the CONTRACTOR shall provide approved equipment.

303.4.8. Miscellaneous Finishing Equipment. The CONTRACTOR shall furnish a broom of the push broom type not less than 18-in. in width with stiff bristles for the final surface finish of concrete base or as the OWNER directs.

The CONTRACTOR shall furnish a sufficient number of bridges equipped to ride on the forms and span the pavement for finishing operations and for the installation and finishing of joints. The CONTRACTOR shall furnish, operate and maintain at least two standard 10-ft. steel straightedges and all necessary finishing and edging tools as may be required to complete the pavement in accordance with the plans and specifications.

303.5. CONSTRUCTION METHODS

303.5.1. Subgrade. When manipulation or treatment of subgrade is required on the plans, the work shall be performed in proper sequence with the preparation of the subgrade for pavement.

The roadbed shall be excavated and shaped in conformity with the typical sections and to the lines and grades shown on the plans or established by the OWNER. Material excavated in the preparation of the roadbed in excess of that needed to properly construct the subgrade, shoulders, slopes or parkway shall be wasted. If additional material is required, it shall be secured from sources indicated on the plans or designated by the OWNER. All holes, ruts and depressions shall be filled with suitable material and, if required, the subgrade shall be thoroughly wetted and reshaped. Irregularities of more than ½-in., as shown by straightedge or template, shall be corrected. The subgrade shall be uniformly compacted to at least 95-percent of the maximum density as determined by ASTM D698 Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3). Moisture content shall be within minus-2%- to plus-4%-of-optimum. The prepared subgrade shall be wetted down sufficiently in advance of placing the pavement to insure its being in a firm and moist condition for at least 2-in. below the surface. Sufficient subgrade shall be prepared in advance to insure satisfactory prosecution of the work. No hauling or equipment shall be permitted on the finished subgrade.

The CONTRACTOR shall notify the OWNER at least three working days in advance of its intention to place concrete pavement.

Density tests must be taken no more than 72-hours prior to placement of concrete. After the specified moisture and density are achieved, the CONTRACTOR shall maintain the subgrade moisture and density in accordance with Item 301. Subgrade, Subbase, and Base Preparation until the pavement is placed. In the event that rain or other conditions may have adversely affected the condition of the subgrade or base, additional tests may be required as directed by the OWNER.

303.5.2. Placing and Removing Forms. Forms shall be set to line and grade at least 200-ft., where practicable, in advance of the paving operations. Forms shall be adequately staked with at least three pins per 10-ft. section and capable of resisting the pressure of concrete placed against them and the thrust and the vibration of the construction equipment operating upon them without appreciable springing or settlement. Forms shall be jointed neatly and tightly and set with exactness to the established grade and alignment. Forms must be in firm contact with the subgrade throughout their length and base width. If the subgrade becomes unstable, forms shall be reset, using heavy stakes, or other additional supports may be necessary to provide the required stability.

303.5.2.1. Settling. When forms settle over ⅛-in. under finishing operations, paving operations shall be stopped, the forms reset to line and grade and the pavement then brought to the required section and thickness.

303.5.2.2. Cleaning and Oiling. Forms shall be thoroughly cleaned after each use and well-oiled before reuse.

303.5.2.3. Removal. Forms shall remain in place a minimum of twelve hours or more as required by the OWNER. At the time the forms are removed, any honeycomb shall be rubbed with grout and sealed with a curing compound.

303.5.2.4. Curb. Superimposed or monolithic curb shall be formed from the flowline of the gutter to the top of the curb. All expansion joints in the curbs shall conform to the joint locations in the slab.

303.5.3. Placing Reinforcing Steel, Tie, and Dowel Bars. When reinforcing steel, welded wire mesh, tie bars, dowels, etc., are required, they shall be placed as shown on the plans. All reinforcing shall be clean, free from rust in the form of loose or objectionable scale, and of the type, size and dimensions shown on the plans. Reinforcing bars shall be securely wired together at the alternate intersections and all splices and shall be securely wired to each intersection dowel and load-transmission unit intersected. All bars shall be installed in their required position as shown on the plans.

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

303.5.3.1. Installation. All reinforcing bars and bar mats shall be installed in the slab at the required depth below the finished surface and supported by and securely attached to bar chairs installed on prescribed longitudinal and transverse centers as shown by sectional and detailed drawings on the plans. After the reinforcing steel is securely installed above the subgrade, as specifically required by plans and as herein prescribed, there shall be no loading imposed upon (or walking upon) the bar mats or individual bars before or during the placing or finishing of the concrete.

303.5.3.2. Welded Wire Mats. Where welded wire fabric reinforcement mats are required by the plans, or permitted as an alternate by the OWNER, the concrete shall be placed and struck off by means of a template to the depth below the finished surface as specified for the location of the mesh. Welded wire mats, conforming to the specified side lap and end splice requirements as detailed on the plans, shall be placed upon the struck surface. The remainder of the concrete shall be placed thereupon with finishing operations proceeding immediately. There shall be no loading imposed upon the mesh mats after installation in the slab concrete.

303.5.3.3. Assembly. Expansion joints or dummy joints which may require an assembly of parts supported by special devices shall be completely assembled and rigidly supported in the correct position well in advance of the placing of concrete.

303.5.4. Joints.

303.5.4.1. Joint Dimensions. The width of the joint shall be shown on the plans, creating the joint sealant reservoir. The depth of the joint shall be shown on the plans. Dimensions of the sealant reservoir shall be in accordance with manufacturer's recommendations. Normal width/depth ratios are 1 to 1, not to exceed 1 to 1½. After curing, the joint sealant shall be ⅛-in. to ¼-in. below the pavement surface at the center of the joint.

303.5.4.2. Expansion Joints. Expansion joints shall be installed perpendicularly to the surface and to the centerline of the pavement at the locations shown on the plans.

Refer to Item 702.5.4.1. Expansion Joints for more information.

303.5.4.2.1. Joint Filler. Joint filler shall be as specified in Item 303.2.12. Joint Filler, as approved by OWNER, of the size and shape shown on the plans.

Board joint material with less than 25-percent of moisture at the time of installation shall be thoroughly wetted on the job. Green lumber of much higher moisture content is desirable and acceptable.

The joint filler shall be appropriately drilled to admit the dowel bars when required. The bottom edge of the filler shall extend to or slightly below the bottom of the slab. The top edge shall be held approximately ½-in. below the finished surface of the pavement in order to allow the finishing operations to be continuous. Where the joint filler is of a premolded asphaltic type, the top edge shall be protected, while the concrete is being placed and finished, by a metal cap of at least 10 gauge material having flanges not less than 1½-in. in depth. The channel cap may remain in place during the joint finishing operations to serve as a guide for tooling the edges of the joint. After the removal of the side forms, the ends of the joints at the edges of the slab shall be carefully opened for the entire depth of the slab.

303.5.4.2.2. Curb. Where a superimposed curb or a separate curb and gutter may be used, the expansion joints therein shall coincide and be continuous with the pavement joint and of the same size and type.

303.5.4.2.3. Proximity to Existing Structures. When the pavement is adjacent to or around existing structures, expansion joints shall be constructed in accordance with the details shown on the plans.

303.5.4.2.4. Dowel Bars. Dowel bars, where required on the plans, shall be installed through the predrilled joint filler and rigidly supported in true horizontal and vertical positions by an assembly of bar chairs and dowel holders welded to transverse bars extending across the slab and placed on each side of the joint. The chair assembly shall be similar and equal to that shown on the plans and shall be approved by the OWNER prior to extensive fabrication.

303.5.4.3. Contraction Joints. Contraction or dummy joints shall be installed at the locations and at the intervals shown on the plans in accordance with this section and Item 402.3. Sawing. The joints shall be constructed by sawing to a ¼-in. width and to a depth of ¼ of the pavement thickness, or deeper if so indicated on the plans. Unless otherwise specified on the plans, joints shall be sawed into the completed pavement surface as soon after initial concrete set as possible so that some raveling of the green concrete is observed in order for the sawing process to prevent uncontrolled shrinkage cracking. If sharp edge joints are being obtained, the sawing process shall be sped up to the point where some raveling is observed. Damage by blade action to the slab surface and to the concrete immediately adjacent to the joint shall be minimized. Any portion of the curing membrane which has been disturbed by sawing operations shall be restored by spraying the areas with additional curing compound. The sawed groove shall immediately be thoroughly cleaned for the full depth and width of the joint and filled. The type of equipment and method for performing this work shall be approved by the OWNER.

303.5.4.4. Construction Joints. Construction joints formed at the close of each day's work or when the placing of concrete has been stopped for 30-minutes or longer shall be constructed by use of metal or wooden bulkheads cut true to the section of the finished pavement and cleaned and oiled. Wooden bulkheads shall have a thickness of not less than 1½-in. Longitudinal bars shall be held securely in place in a plane perpendicular to the surface and at right angles to the centerline of the pavement. Edges shall be rounded to ¼-in. radius. Any surplus concrete on the subgrade shall be removed upon the resumption of the work.

In no case shall an emergency construction joint be placed within 8-ft. following a regular installation of expansion or contraction joint. If the emergency construction joint should fall within this limitation, the concrete shall be removed back to the previously installed joint.

Refer to Item 702.5.4.2. Construction Joints for more information.

303.5.4.5. Longitudinal Parting Strips. Longitudinal parting strips or planes of weakness, when required, shall be accurately placed as shown on the plans.

303.5.4.6. Longitudinal Construction Joints. Longitudinal construction joints shall be of the type shown on the plans. Longitudinal joints shall be constructed accurately to required lines in order to coincide with traffic lane lines. No width between longitudinal construction joints shall exceed 24-ft., unless specifically authorized or directed by the OWNER in writing.

303.5.4.7. Joint Sealing. Routine pavement joints shall be filled to a depth of 1½-in. Materials shall generally be handled and applied according to the manufacturer's recommendations, with additional requirements as stated herein.

303.5.4.7.1. Hot Poured Polymer. The sealing filler shall be melted in an approved oil-batch kettle with continuous mechanical agitation. The kettle shall be equipped with temperature indicators. The OWNER shall determine the optimum temperature for proper pouring fluidity, and the CONTRACTOR shall maintain the material within close range of optimum temperature. At no time shall the temperature exceed 450°F. Joint sealing compound shall not be poured at atmospheric temperatures below 32°F.

303.5.4.7.2. Ready-Mixed Cold-Applied. Permeation of joints shall principally be achieved without the task of squeegeeing. However, squeegeeing is recommended to assist permeation and to allow sealant to become rapidly tack-free. Sealant shall "set" in a fixed position within 40-minutes after application, to where traffic may be restored to the pavement without the effects of "tracking." "Tracking" shall be averted without the use of topping materials such as sand.

303.5.5. Placing Concrete. Unless otherwise shown on the plans, the concrete shall be placed using either forms or slipform paver. The concrete shall be rapidly deposited on the subgrade in successive batches and shall be distributed to the required depth and for the entire width of the pavement by shoveling or other approved methods. Any concrete not placed as herein prescribed within the time limits specified in Table 303.5.5.(a) Concrete Placement will be rejected.

Table 303.5.5.(a) Concrete Placement Temperature –Time Requirements

Concrete Temp (at point of placement)	Max Time - minutes (no retarding agent)	Max Time – minutes (with retarding agent)[1]
Non-Agitated Concrete		
All temperatures	30	45
Agitated Concrete		
Above 90°F	45	75
Above 75 F thru 90°F	60	90
75°F and Below	90	120

1. Normal dosage of retarder.

Where bar mats or wire mesh reinforcing is specified, method of concrete placement shall be in accordance with Item 303.5.3. Placing Reinforcing Steel, Tie, and Dowel Bars. Rakes shall not be used in handling concrete. The placing operation shall be continuous. At the end of the day, or in case of unavoidable interruption or delay of more than 30-minutes, a transverse construction joint shall be placed in accordance with Item 303.5.4.4. Construction Joints.

303.5.5.1. Honeycombing. Special care shall be taken in placing and spading the concrete against the forms and at all joints and assemblies so as to prevent honeycombing. Excessive voids and honeycombing in the edge of the pavement, revealed by the removal of the side forms, may be cause for rejection of the section of slab in which the defect occurs.

303.5.5.2. Weather Conditions. Except by specific written authorization of the OWNER, no concrete shall be placed when the air temperature is less than 40°F and falling but may be placed when the air temperature is above 35°F and rising, the temperature being taken in the shade away from artificial heat. When and if such permission is granted, the CONTRACTOR shall furnish sufficient protective material and devices to enclose and protect the fresh concrete in such a way as to maintain the temperature of the air surrounding the fresh concrete at not less than 50°F for a period of at least 5-days.

Except by specific written authorization of the OWNER, no concrete shall be placed when the concrete temperature is higher than 95°F. CONTRACTOR shall take appropriate measures including chilling and reduction of time intervals between batching and placing.

It is to be distinctly understood that the CONTRACTOR is responsible for the quality and strength of the concrete placed under any weather conditions. No concrete shall be placed on a frozen subgrade.

303.5.5.3. Time. Concrete shall not be placed before the time of sunrise and the surface finishing shall be completed prior to sunset unless otherwise authorized by the OWNER.

303.5.6. Finishing.

303.5.6.1. Machine. When the concrete has been deposited, it shall be approximately leveled and then struck off to such elevation that, when mechanically screeded and tamped, the concrete shall be thoroughly compacted and finished to the required line, grade and section with all surface voids filled. Where bar mats or wire mesh reinforcing is specified, method shall be in accordance with Item 303.5.3. Placing Reinforcing Steel, Tie, and Dowel Bars.

303.5.6.1.1. Tolerance Limits. While the concrete is still workable, it shall be tested for irregularities with a 10-ft. straightedge placed parallel to the centerline of the pavement so as to bridge depressions and to touch all high spots. Ordinates measured from the face of the straightedge to the surface of the pavement shall at no place exceed $^{1}/_{16}$ inch-per-foot from the nearest point of contact. In no case shall the maximum ordinate to a 10-ft. straightedge be greater than ⅛-in. Any surface not within the tolerance limits shall be reworked and refinished.

303.5.6.1.2. Edging. The edges of slabs and all joints requiring edging shall be carefully tooled with an edger of the radius required by the plans at the time the concrete begins to take its “set” and becomes non-workable. All such work shall be left smooth and true to lines.

303.5.6.1.3. Stamp or Die. All concrete including curbs, curb with gutter, sidewalks, alleys, driveways and structures shall be marked by means of a substantial stamp or die so designed to make an impression in the finish of the concrete. The stamp or die shall designate the firm name or CONTRACTOR and the month and year in which the work was done. The design of the stamp or die shall be approved by the OWNER.

303.5.6.2. Hand. Hand finishing shall be permitted only in intersections and areas inaccessible to a finishing machine. The addition of one-sack of cement per cubic-yard shall be required for all hand finish concrete.

When the hand method of striking off and consolidating is permitted, the concrete, as soon as placed, shall be approximately leveled and then struck off and screeded to such elevation above grade that, when consolidated and finished, the surface of the pavement shall be at the grade elevation shown on the plans. The entire surface shall then be tamped and the concrete consolidated so as to insure maximum compaction and a minimum of voids. For the strike off and consolidation, both a strike template and tamping template shall be provided on the work. In operation the strike template shall be moved forward with a combined longitudinal and transverse motion and so manipulated that neither end of the template is raised from the forms during the striking-off process. A slight excess of material shall be kept in front of the cutting edge at all times.

The straightedge and joint finishing shall be as hereinabove prescribed.

303.5.7. Curing. The curing of concrete pavement shall be thorough and continuous throughout the entire curing period. Failure to provide proper curing as herein prescribed shall be considered as sufficient cause for immediate suspension of the paving operations. The curing method as herein specified does not preclude the use of any of the other commonly used methods of curing, and the OWNER may approve another method of curing if so requested by the CONTRACTOR. If any selected method of curing does not afford the desired results, the OWNER shall have the right to order that another method of curing be instituted. Immediately after the finishing of the surface, the pavement shall be covered with a continuous, uniform water-impermeable coating of the type specified in Item 303.2.13. Curing Materials. After removal of the side forms, the sides of the slab shall receive a like coating before earth is banked against them. The solution shall be applied, under pressure with a spray nozzle, in such a manner as to cover the entire surfaces thoroughly and completely with a uniform film.

The rate of application shall be such as to insure complete coverage and shall not exceed 200-square-feet-per-gallon of curing compound. When thoroughly dry, it shall provide a continuous and flexible membrane, free from cracks or pinholes, and shall not disintegrate, check, peel or crack during the curing period. If for any reason the seal is broken during the curing period, it shall be immediately repaired with additional sealing solution.

When tested in accordance with ASTM C156 Water Retention by Concrete Curing Materials, the curing compound shall provide a film which shall have retained within the test specimen a percentage of the moisture present in the specimen when the curing compound was applied according to Table 303.5.7.(a) Water Retention by Curing Materials.

Table 303.5.7.(a) Water Retention by Curing Materials

Time	Minimum Retained Moisture
After 24-hours	97%
After 3-days	95%
After 7-days	91%

303.5.8. Opening Pavement to Traffic. All traffic shall be excluded from the pavement for a period of not less than 14-days or until field cured test specimens indicate concrete meets at least 75% of design strength, or as otherwise approved by the OWNER. In all cases the pavement shall be cleaned and joints shall be filled and trimmed before being opened to traffic.

303.5.8.1. Traffic Access. When it is necessary to provide for traffic across the pavement, the CONTRACTOR shall, at its own expense, construct suitable and substantial crossings over the concrete which shall be adequate for the traffic using same.

303.5.8.2. Time. Opening pavement to traffic shall not relieve the CONTRACTOR of responsibility for the work and shall not in any way affect the time charge on the entire project. The number of days stated in the contract shall govern for the completion of the entire work covered by the contract.

303.5.9. Monolithic Curb. Concrete for monolithic curb shall be the same as for the pavement and, if carried back from the paving mixer, shall be placed within 20-minutes after being mixed. Concrete may be placed from the separate mixer if desired but in any case must be placed while the pavement concrete is still plastic. After the concrete has been struck off and sufficiently set, the exposed surfaces shall be thoroughly worked with a float. The exposed edges shall be rounded by the use of an edging tool to the radius indicated on the plans. When the concrete in the curb has been sufficiently set, the inside form shall be carefully removed and the surface may be plastered with a mortar consisting of one part of Portland cement and two parts fine aggregate. The mortar shall be applied with a template or "mule" made to conform to curb dimensions. All exposed surfaces of curb shall be brushed to a smooth and uniform surface.

303.5.10. Superimposed Curb. When sawed joints are used, curbs shall be doweled as shown on the plans and poured after sawing. Doweled curbs which are placed with an extrusion machine shall have a mixture that conforms to Item 303.3. Mix Design and Mixing Concrete for Pavement.

303.5.11. Slip Form Paving. At the option of the CONTRACTOR, and with the approval of the OWNER, concrete pavement may be constructed by the use of slip form paving equipment.

The concrete, for the full paving width, shall be effectively consolidated by internal vibration with transverse vibrating units or with a series of longitudinal vibrating units loaded with the specified thickness of pavement section and at a minimum distance ahead of the screed equal to the pavement thickness.

When concrete is being placed adjacent to an existing pavement, that part of the equipment which is supported on the existing pavement shall be equipped with protective pads on crawler tracks or rubber-tired wheels offset to run a sufficient distance from the edge of the pavement to avoid breaking or cracking the pavement edge.

Final finishing for slip form pavement construction shall be to the tolerance as specified in Item 303.5.6. Finishing.

303.6. ALLEY PAVING

Alley paving shall be constructed in accordance with the specifications for street paving hereinbefore described, in accordance with the details shown on the plans, and with the following additional provisions:

Alley paving shall be constructed to one of the typical cross sections shown on the plans.

Transverse expansion joints of the type shown on the plans shall be constructed at the property line on each end of the alley with a maximum spacing of 600-ft. Transverse contraction and dummy joints shall be placed at the spacing shown on the plans. Contraction and dummy joints shall be formed in such a manner that the required joints shall be produced to the satisfaction of the OWNER. All joints shall be filled with top seal in accordance with the requirements of Item 303.5.4. Joints.

303.7. PAVEMENT LEAVEOUTS

Pavement leaveouts as necessary to maintain and provide for local traffic shall be provided at location indicated on the plans or as directed by the OWNER. The extent and location of each leaveout required and a suitable crossover connection to provide for traffic movements shall be determined in the field by the OWNER. Left or right-turn lanes and median openings shall not be considered as pavement leaveouts.

303.8. PAVEMENT TESTING AND EVALUATION

303.8.1. Testing of Materials. Samples of all materials for test shall be made at the expense of the OWNER, unless otherwise specified in the special provisions or in the plans. In the event the initial sampling and testing does not comply with the specifications, all subsequent testing of the material in order to determine if the material is acceptable shall be at the CONTRACTOR'S expense at the same rate charged by the

commercial laboratories. All testing shall be in accordance with applicable ASTM Standards and concrete testing technician must be ACI certified or equivalent.

303.8.2. Pavement Thickness Test. Upon completion of the work and before final acceptance and final payment shall be made, pavement thickness test shall be made by the OWNER. The number of tests and location shall be at the discretion of the OWNER, unless otherwise specified in the special provisions or on the plans. The cost for the initial pavement thickness test shall be the expense of the OWNER. In the event a deficiency in the thickness of pavement is revealed during normal testing operations, subsequent tests necessary to isolate the deficiency shall be at the CONTRACTOR'S expense. The cost for additional coring test shall be at the same rate charged by commercial laboratories.

Where the average thickness of pavement in the area found to be deficient in thickness by more than 0.20-in., but not more than 0.50-in., upon discretion of the OWNER payment shall be made at an adjusted price as specified in Table 303.8.2.(a) Concrete Pavement Deficiency.

Table 303.8.2.(a) Concrete Pavement Deficiency

Deficiency in Thickness Determined By Cores	Proportional Part of Contract Price
Inches	**Allowed**
0.00 — 0.20	100 percent
0.21 — 0.30	80 percent
0.31 — 0.40	70 percent
0.41 — 0.50	60 percent

Any area of pavement found deficient in thickness by more than 0.50-in. but not more than 0.75-in. or $^1/_{10}$ of the plan thickness, whichever is greater, shall be evaluated by the OWNER. If, in the judgment of the OWNER, the area of such deficiency should not be removed and replaced, there shall be no payment for the area retained. If, in the judgment of the OWNER, the area of such deficiency warrants removal, the area shall be removed and replaced, at the CONTRACTOR'S entire expense, with concrete of the thickness shown on the plans. Any area of pavement found deficient in thickness by more than 0.75-in. or more than $^1/_{10}$ of the plan thickness, whichever is greater, shall be removed and replaced, at the CONTRACTOR'S entire expense, with concrete of the thickness shown on the plans.

No additional payment over the contract unit price shall be made for any pavement of a thickness exceeding that required by the plans.

303.8.3. Pavement Strength Test.

303.8.3.1. For Standard Classes of Concrete. During the progress of the work, the CONTRACTOR shall cast test cylinders, in accordance with ASTM C31 Standard Practice for Making and Curing Concrete Test Specimens in the Field, to maintain a check on the compressive strengths of the concrete being placed.

In accordance with ASTM C31 and ASTM C172 Standard Practice for Sampling Freshly Mixed Concrete, four test cylinders shall be taken from a representative portion of the concrete being placed for every 150-cubic yards of concrete pavement placed, but in no case shall less than 2 sets of cylinders be taken from any one day's placement. For smaller placements, the testing frequency may be adjusted at the OWNER'S discretion.

After the cylinders have been cast, they shall remain on the job site and then transported, moist cured, and tested by the OWNER in accordance with ASTM C31 and ASTM C39 Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.

In each set, one of the cylinders shall be tested at 7-days, two cylinders shall be tested at 28-days, and one cylinder shall be held or tested at 56-days, if necessary.

If the 28-day test results indicate deficient strength, the CONTRACTOR may, at its option and expense, core the pavement in question and have the cores tested by an approved laboratory, in accordance with ASTM C42 Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of

Concrete and ACI 318 protocol, except the average of all cores must meet 100% of the minimum specified strength, with no individual core resulting in less than 90% of design strength, to override the results of the cylinder tests.

The CONTRACTOR shall be responsible for the proper storage, maintenance, and any required curing of concrete test samples made by the OWNER. The CONTRACTOR shall provide and maintain curing facilities for the purpose of curing concrete test specimens on site in accordance with ASTM C31. The cost of all materials used in test specimens and the cost of storing, maintaining and of providing and maintaining curing facilities will not be paid for as a separate contract pay item, and the costs thereof shall be considered incidental to the contract pay items provided.

Cylinders and/or cores must meet minimum specified strength. Pavement not meeting the minimum specified strength shall be subject to the money penalties or removal and replacement at the CONTRACTOR'S expense as shown in Table 303.8.3.1.(a) Standard Class Concrete Deficiency Penalties.

Table 303.8.3.1.(a) Standard Class Concrete Deficiency Penalties.

Percent Deficient	Percent of Contract Price Allowed
Greater Than 0% — Not More Than 5%	95-percent
Greater Than 5% — Not More Than 10%	90-percent
Greater Than 10% — Not More Than 15%	80-percent
Greater Than 15%	60-percent or removed and replaced at the entire cost and expense of CONTRACTOR as directed by OWNER.

The amount of penalty shall be deducted from payment due to CONTRACTOR; such penalty deducted is to defray the cost of extra maintenance.

These requirements are in addition to the requirements of Item 303.9. Measurement and Payment.

The strength requirements for structures and other concrete work are not altered by this special provision.

No additional payment over the contract unit price shall be made for any pavement of strength exceeding that required by plans and/or specifications.

303.8.3.2. For Performance Classes of Concrete. During the progress of the work, the CONTRACTOR shall cast test cylinders, in accordance with ASTM C31 Standard Practice for Making and Curing Concrete Test Specimens in the Field, to maintain a check on the compressive strengths of the concrete being placed.

In accordance with ASTM C31 and ASTM C172 Standard Practice for Sampling Freshly Mixed Concrete, four test cylinders shall be taken from a representative portion of the concrete being placed for every 150-cubic yards of concrete pavement placed, but in no case shall less than 2 sets of cylinders be taken from any one day's placement.

After the cylinders have been cast, they shall remain on the job site and then transported, moist cured, and tested by the OWNER in accordance with ASTM C31 and ASTM C39 Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.

In each set, one of the cylinders shall be tested at 7-days, two cylinders shall be tested at 28-days, and one cylinder shall be held or tested at 56-days, if necessary.

If the 28 day test results indicate deficient strength, the CONTRACTOR may, at its option and expense, core the pavement in question and have the cores tested by an approved laboratory, in accordance with ASTM C42 Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete and ACI 318 protocol, to override the results of the cylinder tests.

The CONTRACTOR shall be responsible for the proper storage, maintenance, and any required curing of concrete test samples made by the OWNER. The CONTRACTOR shall provide and maintain curing facilities for the purpose of curing concrete test specimens on site in accordance with ASTM C31. The cost of all materials used in test specimens and the cost of storing, maintaining and of providing and maintaining curing facilities will not be paid for as a separate contract pay item, and the costs thereof shall be considered incidental to the contract pay items provided.

Cylinders and/or cores must meet the specified strength in accordance with ACI 318 protocol. Pavement not meeting the specified strength shall be subject to the money penalties or removal and replacement at the CONTRACTOR'S expense as shown in Table 303.8.3.2.(a) Performance Class Concrete Deficiency Penalties.

Table 303.8.3.2.(a) Performance Class Concrete Deficiency Penalties.

Percent Deficient	Percent of Contract Price Allowed
Greater Than 0% — Not More Than 5%	95-percent
Greater Than 5% — Not More Than 10%	90-percent
Greater Than 10% — Not More Than 15%	80-percent
Greater Than 15%	60-percent or removed and replaced at the entire cost and expense of CONTRACTOR as directed by OWNER.

The amount of penalty shall be deducted from payment due to CONTRACTOR; such penalty deducted is to defray the cost of extra maintenance.

These requirements are in addition to the requirements of Item 303.9. Measurement and Payment.

The strength requirements for structures and other concrete work are not altered by this special provision.

No additional payment over the contract unit price shall be made for any pavement of strength exceeding that required by plans and/or specifications.

303.8.4. Random Drying Shrinkage Cracks and Stress Cracks. Random drying shrinkage cracks or stress cracks of widths greater than 0.025-inches in recently placed reinforced Portland cement concrete pavement placed on stabilized subbase or slabs on grade are subject to being removed and replaced at the discretion of the OWNER. Random drying shrinkage cracks or stress cracks of any nature in recently placed non-reinforced Portland cement concrete pavement placed on non-stabilized subbase or slabs on grade are subject to being removed and replaced at the discretion of the OWNER. Recently placed concrete pavement or slabs on grade are those for which the one-year maintenance bond has not expired. Routing, by any means, and sealing random cracks will not be permitted. When Portland cement concrete pavement or slabs on grade must be removed and replaced, the area of removal must extend from the nearest contraction or dummy joint or construction joint a minimum distance of 10-feet, measured parallel to the longitudinal axis of the pavement, and include that portion of the concrete pavement or slab on grade containing the random crack. A sawed dummy joint will be required to be sawed across the opposing, non-damaged, slab in line with the saw cut made for the removal of the damaged slab. The area of removal and replacement of slabs containing longitudinal random cracks will be determined by the OWNER. Randomly cracked Portland cement concrete sidewalks will require removal and replacement of only the five-feet long section or sections containing random cracks.

303.9. MEASUREMENT AND PAYMENT

Portland cement concrete pavement shall be measured by the square-yard of completed and accepted pavement. Measurement for reinforced concrete pavement shall be by the square-yard measured in its final position.

The work performed and material furnished as prescribed by this item and measured as provided in this item shall be paid for at the unit price bid per square-yard for concrete pavement or the adjusted unit price for pavement of deficient thickness as provided under Pavement Thickness Test and Pavement Strength Test, which price shall be full compensation for shaping and fine grading the roadbed, including furnishing and applying all water required; for furnishing, loading and unloading, storing, hauling and handling all concrete ingredients, including all freight and royalty involved; for mixing, placing, finishing and curing all concrete; for furnishing and installing all reinforcing steel; for furnishing all materials and placing longitudinal, warping, expansion, and contraction joints, including all steel dowels, dowel caps and load transmission units required, wire and devices for placing, holding and supporting the steel bar, load transmission units, and joint filler material in the proper position; for coating steel bars where required by the plans; for all manipulations, labor, equipment, appliances, tools, traffic provisions and incidentals necessary to complete the work.

ITEM 305. MISCELLANEOUS ROADWAY CONSTRUCTION

305.1. CONCRETE CURB AND GUTTER

305.1.1. Description. Curb and gutter shall be of the type specified and shall be constructed to the size, shape, lines and grade as shown on the plans or as directed by the OWNER. Variations in size and shape may be made to fit individual special conditions.

305.1.2. Materials. All materials used in concrete herein specified shall conform to the requirements of the applicable sections of Item 303. Portland Cement Concrete Pavement of these specifications and to additional requirements herein included.

305.1.3. Construction Methods.

305.1.3.1. Excavation. Excavation shall be as provided in Item 203.2. Unclassified Excavation, and as shown on the plans. Asphalt millings or extra depth concrete shall be used to correct grade deficiencies identified after subgrade has been checked.

305.1.3.2. Reinforcing Steel. All steel reinforcement shall be accurately placed as shown on the plans and held in place during progress of concreting by such effective means that it shall not be moved out of true position. All bars shall be wired at their intersections and at all laps or splices. All bars at splices shall be lapped a minimum of 20-diameters of the bar or 12-in., whichever is greater.

All reinforcement necessary for a section of concrete shall be placed and approved by the OWNER before any concrete is deposited in the section. All steel must be free from paint and oil and all loose scale, rust, dirt and other foreign substances shall be completely removed before using.

305.1.3.3. Forms. All forms shall be of wood or steel, straight, free of warp and framed, braced or staked in a substantial and approved manner so as to insure perfect alignment and grade. All forms shall be clean and shall be oiled immediately before concreting. Care shall be taken in removing forms to prevent marring or spalling of the concrete. Forms shall extend the full depth of concrete and be a minimum of $1^{5}/_{8}$-in. in thickness or equivalent when wooden forms are used, or be of a gauge that shall provide equivalent rigidity and strength when metal forms are used.

For curves with a radius of less than 250-ft., acceptable flexible metal or wood forms shall be used.

All forms showing a deviation of ⅛-in. in 10-ft. from a straight line shall be rejected.

305.1.3.4. Expansion Joints. Expansion joints shall be constructed using expansion joint material of an approved type. Expansion joints shall be placed in the curb and gutter at 200-ft. intervals and at intersection returns and other rigid structures, or as otherwise specified by the OWNER. Tooled joints shall also be placed at 15-ft. intervals or matching abutting sidewalk joints and pavement joints to a depth of ¼ the thickness of the curb. Expansion joints shall also be placed at all intersections with concrete driveways, curbs, buildings and other curbs and gutters. All expansion joints shall be not less than ½-in. in thickness, extending the full depth of the concrete and shall be perpendicular and at right angles to the face of the curb. Any expansion material extending above the finished work shall be neatly trimmed to the surface of the finished work. The expansion joints in concrete pavement shall coincide with the expansion joints in the curb and gutter and sidewalk. Longitudinal dowels, across the expansion joints in the curb and gutter, shall be required. There shall be three No. 4 round, smooth bars for dowels at each expansion joint, spaced in accordance with standard reinforcement steel specifications. The dowel shall be a minimum of 24-in. in length. One-half of the dowel shall be coated with asphalt and terminated with an expansion cap. The cap shall provide a minimum of 1-in. free expansion. Dowels shall be supported by an approved method to provide a true horizontal and longitudinal alignment.

In the event that concrete pavement is to be placed in the street, the contraction (dummy) joints in the curb, gutter and/or combined curb and gutter shall be in strict alignment with the contraction (dummy) joints in the pavement and may be marked with an approved tool to the depth designated by the OWNER. If the joints are not constructed by marking, they shall be sawed at the time of sawing joints in the concrete slab and to the same depth as those in the slab. Expansion joints of the size of those in the pavement shall be placed through the curb and gutter at the point of, and in strict alignment with, expansion joints in the pavement.

All joints through the gutters (not curb) shall be sealed with hot-poured polymer sealer unless otherwise specified.

All joints shall be constructed in a neat and workmanlike manner, with edges rounded, in conformity with the plans and specifications and at location as shown on the plans or as designated by the OWNER.

305.1.3.5. Concrete Placement. Concrete shall be placed in accordance with Item 303. Portland Cement Concrete Pavement.

Concrete shall be deposited so as to maintain a horizontal surface and shall be thoroughly and continuously worked into all spaces and around any reinforcement so as to form a dense voidless mass. The coarse aggregate shall be worked away from contact with the forms so as to form a smooth, hard exposed concrete surface.

The concrete for curb and gutter shall preferably be placed continuously between expansion joints. If construction joints are allowed at other locations by the OWNER, they shall be properly constructed with wooden bulkheads so as to completely separate adjacent concrete sections.

Integral curb, with or without gutter, when designated in the plans or specifications, shall be placed while the concrete in the base or pavement is still plastic and shall be spaded and consolidated with the concrete slab in order that a thorough bond shall be obtained.

Integral curb, with or without gutter, shall be placed in sections equal to the adjoining concrete slab length, with expansion joints provided as specified herein.

Where curb and gutter is not adjacent to new pavement, 2-in. of sand cushion shall be used. After the fine grading has been completed, a 2-in. layer of sand or suitable gravel cushion shall be evenly spread over the subgrade for curb and gutter, thoroughly wetted and tamped into place to the satisfaction of the OWNER. The forms shall be placed upon this sand or gravel base. A screed shall be used to shape the sand cushion to fit a plane parallel to the top of gutter. A curb and gutter machine may be used, if approved by the OWNER.

305.1.3.6. Finishing. After the concrete has been struck off and while it is still plastic, the exposed surfaces may be plastered with ¼-in. mortar topping. The mortar topping shall be applied with a steel "mule," or a finishing tool or method which produces results equivalent to that obtained with the mule. All exposed surfaces shall then be floated or troweled and lightly brushed as required by the OWNER to produce a smooth and uniform finish. Excess working of the surfaces shall be avoided. Excess water, laitance and inert materials shall be removed from the surfaces.

The top of all the work and the face of all curbs shall be checked for irregularities as soon as the surface is finished, using a 10-ft. straightedge, and the maximum distance from the straightedge to the concrete shall not exceed ¼-in. All variations greater than ¼-in. shall be immediately corrected. All honeycombed areas disclosed by removal of forms shall be immediately chipped out and patched with Portland cement mortar.

305.1.3.7. Curing. After finishing operations are completed, the concrete surface shall be sprayed with concrete curing compound. The surface of the concrete shall be kept thoroughly damp between the completion of the finishing operations and the application of the curing compound. The curing compound shall be applied under pressure, by means of a spray nozzle, at a rate not to exceed 200-sq.-ft.-per-gallon. A minimum of 72-hours curing time shall be required.

Forms shall remain in place at least 12 hours after completion of the concrete placement for the curb and gutter. Should the CONTRACTOR elect to remove the forms before the minimum curing time has elapsed, it shall apply curing compound to the newly exposed vertical faces. Forms for inside curb faces may be removed in approximately 3-hours, provided that the concrete has set sufficiently to permit form removal without curb damage.

305.1.3.8. Finishing Exposed Surfaces. Exposed surfaces of curb and gutter shall receive the type of finish as specified by the OWNER in accordance with Item 702.5.13. Finishing Exposed Surfaces.

305.1.4. Measurement and Payment. Curb and gutter shall be measured by the linear foot in place complete.

The work performed and materials furnished as prescribed in this item, measured as provided in this item, shall be paid for at the contract unit prices bid for curb and gutter, which shall be full compensation for

preparing the subgrade; furnishing and placing all materials, including foundation course, reinforcing steel and expansion joint material; and for all manipulation, labor, tools, equipment and incidentals necessary to complete the work.

305.2. CONCRETE SIDEWALKS, DRIVEWAY APPROACHES, AND BARRIER FREE RAMPS

305.2.1. Description. This item shall govern the construction of barrier free access ramps, concrete sidewalks, driveways and approaches conforming to the lines, grades, locations and designs as indicated on the plans and specifications or as established by the OWNER.

305.2.2. Materials.

305.2.2.1. Concrete. All materials and requirements for concrete shall conform to the requirements of Item 303. Portland Cement Concrete Pavement.

305.2.2.2. Reinforcement. Driveway approaches and walk reinforcing, when required, shall be No. 3 bars on 24-in. centers or No. 4 bars on 30-in. centers. No. 6 gauge, 6-in. x 6-in. wire fabric conforming to Item 303.2.10. Steel Wire Reinforcement may be used only as approved by the OWNER. Sidewalk reinforcing (except in driveway approach) may be No. 3 bars on 24-in. centers or No. 10 gauge, 6-in. x 6-in.

305.2.3. Construction Methods.

305.2.3.1. General. Concrete sidewalks shall have a minimum thickness of 4-in., except that sidewalks constructed in driveway approach sections shall have a minimum thickness equal to that of driveway approach or as called for by plans and specifications within the limits of the driveway approach. Standard slope for walks shall be ¼-in.-per-ft. in the direction of the curb or street with a tolerance of $^{1}/_{8}$-in.-per-ft. The construction of the driveway approach shall include the variable height radius curb in accordance with the plans and details. The drive approach shall have a minimum thickness equal to the thickness of the adjacent street or 6-in., whichever is greater.

Ramps shall comply with provisions of Texas Accessibility Standards including location, slope, width, shapes, texture and coloring.

At the locations shown on the plans or at locations designated by the OWNER, the separate curb, integral curb or curb and gutter shall be laid down to a uniform width of not less than the specified height of the curb from the back of the curb line for access to future driveways. The return radii and partial curb return shall be built from the face of the curb to the back of the curb lay-down.

Where a driveway approach or ramp is to be constructed at a location where there exists a separate curb and gutter, said curb and gutter shall be removed for the full width of the gutter to the nearest joint or to a sawed point at the point of radius. On concrete pavement with monolithic curb, the breakout line shall be 12-in. from the face of the curb line and shall be parallel to it and form a right angle with the concrete surface. The breakout line shall be a sawed groove in accordance with the requirements of Item 402.3. Sawing. Alternately, the OWNER may approve use of equipment designed to cut concrete curbs. All faces and edges exposed as a result of cutting shall be smoothed.

305.2.3.2. Excavation. Excavation required for the construction of sidewalks and driveways shall be to the lines and grades as established by the OWNER or as shown on the plans.

305.2.3.3. Fine Grading. The CONTRACTOR shall do all necessary filling, leveling and fine grading required to bring the subgrade to the exact grades specified and compacted to at least 90-percent of maximum density as determined by ASTM D698 Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3). Moisture content shall be within minus-2- to plus-4-of-optimum. Any over-excavation shall be repaired to the satisfaction of the OWNER.

305.2.3.4. Forms. Forms shall be of wood or metal, of a section satisfactory to the OWNER, straight, free from warp and of a depth equal to the thickness of the finished work. Forms shall be securely staked to line and grade and maintained in a true position during the depositing of concrete.

305.2.3.5. Reinforcement. Steel bar reinforcement, when required, shall be placed according to the methods in Item 303.2.9. Steel Reinforcement. If wire fabric is permitted, it shall be placed in accordance with Item 303.2.10. Steel Wire Reinforcement.

305.2.3.6. Concrete Placement. Concrete placement shall be in accordance with the relevant provisions of Item 303. Portland Cement Concrete Pavement.

305.2.3.7. Finishing. Concrete sidewalks and driveway approaches shall be finished to a true, even surface. They shall be troweled and then brushed transversely to obtain a smooth uniform brush finish. Joint and sides shall be edged with suitable tools.

305.2.3.8. Joints. Expansion joints for sidewalks and driveways shall be formed using expansion joint material of an approved type and shaped to the section. Expansion joints shall be placed in the sidewalk at 40-ft. intervals or as otherwise specified by the OWNER. Expansion joints shall also be placed at all intersections, sidewalks with concrete driveways, curbs, formations, other sidewalks and other adjacent old concrete work. Similar material shall be placed around all obstructions protruding into or through sidewalks or driveways. All expansion joints shall be ½-in. in thickness. Edges of all construction and expansion joints and outer edges of all sidewalks shall be finished to approximately a ½-in. radius with a suitable finishing tool. Sidewalks shall be marked at intervals equal to the width of the walk with a marking tool. When sidewalk is against the curb, expansion joints and tooled grooves shall match those in the curb.

305.2.3.9. Curing. Sidewalks and driveways shall be cured in accordance with the requirements of Item 303. Portland Cement Concrete Pavement.

305.2.4. Measurement and Payment. Measurement for sidewalks, driveway approaches and ramps complete and in place shall be by the square-yard. Measurement of driveway approaches shall start at the back of the laydown curb line and shall include the area of the curb radii. Curbs on driveways shall not be measured separately but shall be included as a part of the driveway concrete. Concrete sidewalks and driveways shall be paid for at the contract unit price bid, which price shall be full compensation for excavating and preparing the subgrade; furnishing and placing all materials, including gravel base and expansion joint materials; and for all manipulation, labor, tools, equipment and incidentals necessary to complete the work.

305.3. CONCRETE MEDIANS

305.3.1. Description. This item shall consist of concrete medians in accordance with these specifications and in conformance with the lines and grades established by the OWNER and details shown on the plans.

305.3.2. Materials. All material requirements for constructing concrete medians shall conform to the requirements of Item 303. Portland Cement Concrete Pavement. Where a monolithic concrete median is indicated, concrete and reinforcement shall match the adjacent pavement.

305.3.3. Construction Methods.

305.3.3.1. Excavation. Excavation and fine grading shall be done according to Item 203.2. Unclassified Excavation, and shall be subsidiary to the item.

305.3.3.2. Forms. Forms, where required, shall conform to the requirements of Item 303. Portland Cement Concrete Pavement and shall be of a depth equal to the depth of the required section. Forms shall be securely staked to line and grade and maintained in a true position during the depositing of concrete.

305.3.3.3. Concrete Placement. Concrete placement shall be in accordance with the relevant provisions of Item 305.1. Concrete Curb and Gutter.

305.3.3.4. Finishing. The surface shall be finished with a float and lightly brushed to obtain a uniform finish. Tooled joints shall be placed longitudinally and transversely at intervals not to exceed 6-ft. center to center, as shown on the plans, or as directed by the OWNER. Joints in the median shall coincide with joints in curb and gutter. Expansion joint material shall be placed between the median and the back of curb and around all obstructions protruding through the concrete median.

305.3.4. Measurement and Payment. Concrete median shall be measured by the square-yard complete in place.

The work performed and materials furnished as prescribed by this item, measured as provided for in this item, shall be paid for at the contract unit price bid for “concrete median,” which price shall be full compensation for constructing concrete median and for preparing the subgrade; furnishing and placing all

materials, including sand cushion, reinforcement and expansion materials; and for all manipulation, labor, tools, equipment and incidentals necessary to complete the work.

305.4. REINFORCED CONCRETE HEADERS

This item shall govern the construction of reinforced concrete header to the size, shape and at the location shown on the plans.

Material requirements shall be the same as those for Item 303. Portland Cement Concrete Pavement.

Concrete header shall be constructed at the location(s) shown on the plans and shall be constructed as shown on the plans in accordance with Item 303. Portland Cement Concrete Pavement.

Concrete header shall be paid by the linear-foot complete in place.

The work performed and materials furnished as prescribed by this item, measured as provided for in this item, shall be paid for at the contract unit price bid for concrete header. This payment shall be full compensation for necessary excavation, reinforcing steel, furnishing and placing concrete, and for all labor, tools, equipment and incidentals necessary to complete the work.

ITEM 401. CRACK SEALING

401.1. GENERAL

Crack sealing compound shall consist of hot poured polymer or ready-mixed cold-applied sealant, or other material approved by the OWNER. It shall not crack or break when exposed to low temperatures. The cured sealant must not pick up or "track" at elevated road temperature.

401.2. MATERIALS

401.2.1. Hot Poured Polymer. The sealing compound shall meet the requirements of Item 303.2.14.1.1. Hot Poured Polymer.

401.2.2. Ready-Mixed Cold-Applied. This sealant shall meet the requirements of Item 303.2.14.1.2. Ready-Mixed Cold-Applied.

401.2.3. Thermoplastic Cold-Applied. If approved by the OWNER, thermoplastic cold-applied jointing material may be used according to manufacturer's recommendations.

401.2.4. Rejection. Materials may be rejected for failure to meet any of the requirements of this specification.

401.3. METHODS

Routine pavement cracks shall be filled to a depth of 1½-in. Materials shall generally be handled and applied according to the manufacturer's recommendations, with additional requirements as stated herein. CONTRACTOR shall clean all cracks prior to installation of crack sealant materials.

401.3.1. Hot Poured Polymer. The sealing compound shall be melted in an approved oil-batch kettle with continuous mechanical agitation. The kettle shall be equipped with temperature indicators. The OWNER shall determine the optimum temperature for proper pouring fluidity, and the CONTRACTOR shall maintain the material within close range of optimum temperature. At no time shall the temperature exceed 450°F. The sealing compound shall not be poured at atmospheric temperatures below 32°F.

401.3.2. Ready-Mixed Cold-Applied. Permeation of cracks shall principally be achieved without the task of squeegeeing. However, squeegeeing is recommended to assist permeation and to allow sealant to become rapidly tack-free. Sealant shall "set" in a fixed position within 40-minutes after application, to where traffic may be restored to the pavement without the effects of "tracking." "Tracking" shall be averted without the use of topping materials such as sand.

401.4. MEASUREMENT AND PAYMENT

Crack sealing shall be measured and paid for on a lump-sum basis for the amount specified in contract documents under "Crack Sealing."

ITEM 402. PAVEMENT CUT, EXCAVATION, AND REPAIR

402.1. GENERAL REQUIREMENTS

Also refer to Standard Drawings 3070A – 3070D for more information.

402.1.1. Marking All pavement cut repairs shall be marked with the CONTRACTOR'S name if required by the OWNER.

402.1.2. Throughfares. No interference with traffic flow on the thoroughfares shall be permitted during the hours of 6:30 a.m. to 9:30 a.m. and 3:30 p.m. to 6:30 p.m., Monday through Friday, unless directed otherwise by the OWNER. Emergency closures during these hours shall be with the approval of the OWNER. Notice of street closures should be provided to the appropriate emergency and/or other department personnel.

Streets shall be maintained in accordance with Item 201.3. Maintenance of Streets and Rights of Way During Construction. When work is stopped for the day, all lanes of arterial or collector streets shall be opened to traffic in accordance with the traffic control plan. A traffic lane shall be considered satisfactorily open if it is paved with hot-mix or cold-mix asphalt paving, or paved with another suitable material approved by the OWNER, or covered.

If the cut is to be covered, the CONTRACTOR shall use steel plates of sufficient strength and thickness to support all the traffic. A transition of hot-mix or cold-mix asphalt conforming to the requirements of Item 302. Asphalt Pavement shall be constructed from the top of the steel plate to the existing pavement to create a smooth riding surface.

Exceptions to these specifications must be approved by the OWNER.

402.2. MINIMUM SIZE OF REPAIR

The following dimensions are minimums and may be superseded by site-specific factors or OWNER requirements. Exact pavement removal locations must be approved by the OWNER prior to construction.

If multiple repairs are closer than 10-ft. apart from edge of one repair to the edge of a second repair, a continuous section shall be replaced.

402.2.1. Sidewalk, Driveway, and Curb and Gutter. Sidewalks shall be removed and replaced to the nearest existing joint.

No sidewalk or driveway section to be replaced shall be smaller than 30-in. in either length or width unless otherwise approved by the OWNER.

A gutter of at least 12-in. may remain, provided that the curb and gutter is not damaged by the construction activity. Damaged curbs shall be replaced at the expense of the CONTRACTOR.

402.2.2. Dimension Parallels the Centerline (Along the Street/Alley). In a concrete paved street or alley, no horizontal dimension of any cut along the street path shall be less than 3-ft. or no less than 1-ft. from the edge of the trench on each end, whichever is greater. In an asphalt paved street or alley, no horizontal dimension of any cut along the street path shall be less than 4-ft. or no less than 2-ft. from the edge of the trench on each end, whichever is greater. Where saw-cut locations coincide with or fall within 3-ft. of the present location of either dummy joints, cold joint, construction joints, expansion joints, or edge, removal shall be to the existing joint or edge. See Standard Drawings 3070C and 3070D.

402.2.3. Dimension Perpendicular to the Centerline (Across the Street) – Multiple Lanes. See Standard Drawing 3070D.

402.2.3.1. Concrete. If the trench edge or point repair is located greater than 1-ft. from a lane line on the side of the line closest to the curb, pavement shall be removed and replaced from the curb to the lane line. If the edge of a trench or point repair is located less than 1-ft. from a lane line on the side of the line closest to the curb, pavement shall be removed and replaced from the curb to the 2nd lane line beyond the trench edge or point repair.

402.2.3.2. Asphalt. If the edge of a trench or point repair is located less than or equal to ½-lane-width but greater than 2-ft. from a lane line, the lane-width of pavement shall be removed and replaced. If the edge of a trench or point repair is located less than 2-ft. from a lane line, the pavement shall be removed and replaced to ½-lane-width on each side. In the lane along the curb, if the trench edge or

point repair plus 2-ft. toward the lane line is less than ½-lane-width, pavement shall be removed and replaced from the curb to ½-lane-width.

402.2.4. Dimension Perpendicular to the Centerline (Across the Street/Alley) – Residential Street or Alley. See Standard Drawing 3070C.

402.2.4.1. Concrete. In any concrete residential street or alley, if the trench edge or point repair is less than 1-ft. from the street or alley centerline, pavement shall be removed and replaced on each side from the trench edge or point repair to a distance 10-ft. from curb, and a minimum of 1-ft. from the trench edge or point repair. If the 1-ft. minimum causes the repair to be closer than 10-ft. from a curb, replace to the curb.

In a concrete residential street or alley less than 30-ft. wide, if the trench edge or point repair is between 1-ft. and 5-ft. from the street or alley centerline, the pavement shall be removed and replaced from the curb to the centerline.

In a concrete residential street or alley 30-ft. wide or greater, if the trench edge or point repair is greater than 5-ft. from the centerline, the pavement shall be removed and replaced from the curb to a distance 10-ft. from the curb. If the trench edge or point repair is more than 1-ft. but less than 5-ft. from the centerline, pavement shall be removed and replaced from the centerline to a distance 10-ft. from the curb.

402.2.4.2. Asphalt. In any asphalt residential street or alley, if the trench edge or point repair is less than 2-ft. from the street or alley centerline, pavement shall be removed and replaced on each side from the trench edge or point repair to a distance 10-ft. from curb, and a minimum of 2-ft. from the trench edge or point repair. If the 2-ft. minimum causes the repair to be closer than 10-ft. from a curb, replace to the curb.

In an asphalt residential street or alley less than 30-ft. wide, if the trench edge or point repair is between 2-ft. and 5-ft. from the street or alley centerline, the pavement shall be removed and replaced from the curb to the centerline.

In a concrete residential street or alley 30-ft. wide or greater, if the trench edge or point repair is greater than 5-ft. from the centerline, the pavement shall be removed and replaced from the curb to a distance 10-ft. from the curb. If the trench edge or point repair is more than 2-ft. but less than 5-ft. from the centerline, pavement shall be removed and replaced from the centerline to a distance 10-ft. from the curb.

402.3. SAWING

402.3.1. Description. This item shall apply in the removal of bituminous or concrete pavement, curb, gutter, sidewalk or driveways. This item shall also govern for the sawing of weakened plane joints (contraction joints). Sawing shall be in accordance with the requirements of this item unless otherwise shown on the plans or in the special provisions.

The removal and replacement of portions of permanent pavement (Portland cement concrete or hot-mix asphalt), drives, slabs, sidewalks, etc. shall require a full-depth of pavement cut to be sawed by the use of an approved power-driven concrete saw in accordance with this specification or as directed by the OWNER.

402.3.2. Equipment. The saw shall be power driven, shall be manufactured especially for the purpose of sawing pavement, shall be suitable for the work to be performed including dust control and shall be maintained in good operating condition.

Saw blades shall make a clean, smooth cut, producing a groove ⅛-in. to ¼-in. wide and to the full depth required by these specifications or as shown on the plans.

The saw, with its control devices, shall be mounted on a sturdy frame supported on rubber-tired wheels.

402.3.3. Construction Methods. Dust and residues from sawing shall be prevented from entering the atmosphere or storm drain.

The edge of pavements, curb, gutter, sidewalk and/or driveways shall be neatly sawed. Saw cuts shall be made perpendicularly to the surface to full pavement depth or as directed by the OWNER. The edges of pavement and appurtenances damaged subsequent to sawing shall again be saw cut to neat straight lines for the purpose of removing the damaged areas. Such saw cuts shall be parallel to the original saw cut.

Concrete sidewalk or driveway to be removed shall be neatly sawed in straight lines either parallel to the curb or at right angles to the alignment of the sidewalk.

402.3.4. Measurement and Payment. Sawing shall be considered subsidiary to the items requiring sawing if no pay item exists in the Contract.

If a pay item exists in the contract for "Saw Cuts," it shall be measured and paid in linear feet of groove actually cut in accordance with the specifications and as directed by the OWNER.

402.4. REPLACING PAVED SURFACES

402.4.1. General. Repairs are to be made as rapidly as possible. Use of fast setting concrete and similar techniques are encouraged. Completion of the job, including replacement of pavement and cleanup, shall normally be accomplished within 10-working-days after the repair work involving the cut is made.

Removal of unsatisfactory work shall begin within 15-days and replacement shall be completed within 30-days of written notification by the OWNER.

The existing pavement shall be sawed in accordance with Item 402.3. Sawing.

The OWNER shall approve embedment specified in accordance with Item 504.5. Embedment, or the embedment standards of the utility owner. The OWNER shall approve embedment compaction. Final backfill shall meet the requirements of Item 504.2.3.4. Flowable or Stabilized Backfill or Item 504.2.3.3. Type "B" Backfill, as determined by the OWNER. Type "B" Backfill shall be compacted to 95% Standard Proctor density.

Parkways shall be treated in accordance with Item 204. Landscaping, including a minimum of 6-in. topsoil and protection and replacement of plants in areas disturbed by construction.

402.4.2. Temporary Pavement Repair. In the event it is necessary to place a temporary surface on any cut opening, it shall be composed of permanent type paving material, specifically excluding gravel or flexible base as the surface material, unless approved by the OWNER. Temporary surfaces shall be adequately compacted and sealed to prevent degradation of the repair during the temporary period. Any temporary surface that fails to provide a nondegraded riding surface shall be removed and replaced at the CONTRACTOR'S expense.

402.4.3. Replacing Curb, Gutter, Sidewalks, Driveways, Etc. Curb, curb with gutter, sidewalks, drives, etc. shall be replaced with Class A or Class PA concrete (Class determined by the OWNER), unless specified otherwise by the OWNER. Replacement shall meet current OWNER standards.

402.4.3.1. Measurement for Replacement of Curb, Gutter, Sidewalks, Driveways, Etc. Removed curb, curb with gutter, sidewalks, drives, etc. shall be measured for payment in square-yard or linear feet as specified in the bid item. The removal or replacement of curbs, curbs and gutters, sidewalks, driveways, etc. in excess of that specified or approved by the OWNER shall be at the expense of the CONTRACTOR.

402.4.4. Replacing Reinforced Concrete Pavement. Pavement shall be removed to a line 12-in. back of the firm banks of the trench or, if within 3-ft. of an existing joint, to the joint. The concrete replacement shall be reinforced with like-size bars as the existing pavement, #4 minimum, drilled 12-in. deep and epoxied in place, spaced on a minimum of 24-in. centers each way.

The concrete shall be Class P2 or Class PP2 (as determined by the OWNER), unless another class is specified by the OWNER. The replacement concrete shall match the thickness of the existing concrete pavement, minimum of 6-in. thick or the minimum thickness of current OWNER standard for the street type.

The new concrete pavement shall be protected from vehicular traffic for a minimum of 7 days or until a minimum flexural strength of 500-psi is obtained or until a compressive strength of 3000-psi is obtained.

402.4.4.1. Measurement of Reinforced Concrete Pavement. Replacement of the reinforced concrete pavement shall be measured at the specified trench width plus 2-ft., thickness in inches, and length in linear feet. Additional reinforced concrete pavement ordered by the OWNER to be placed will be measured as the thickness in inches, and length and width in linear feet.

402.4.5. Replacing Concrete Pavement and Asphalt Overlay. The existing pavement shall be removed to a neat line at least 12-in. back of the firm banks of the trench or, if within 3-ft. of an existing joint, to the joint.

The concrete replacement shall be reinforced with like-size bars as the existing pavement, #4 minimum, drilled 12-in. deep and epoxied in place, spaced on a minimum of 24-in. centers each way.

The asphalt surface course shall be hot-mix asphalt pavement of the type and class indicated on the plans meeting the requirements of Item 302. Asphalt Pavement. Thickness shall match existing pavement or meet the minimum thickness of current OWNER standard for the street type. The joint formed at the interface of the existing pavement and the repair shall be sealed with a material approved by the OWNER.

402.4.5.1. Measurement of Concrete Pavement and Asphalt Overlay. Replacement of the reinforced concrete pavement shall be measured at the specified trench width plus 2-ft., thickness in inches, and length in linear feet. Additional reinforced concrete pavement ordered by the OWNER to be placed will be measured as the thickness in inches, and length and width in linear feet.

Hot-mix asphalt pavement shall be measured at the specified trench width plus 2-ft., thickness in inches, and the length measured in linear feet. Additional asphalt pavement ordered by the OWNER to be placed will be measured as the thickness in inches, and length and width in linear feet.

If paid for, crack sealer shall be measured as indicated on the plans.

402.4.6. Replacing Full Depth Hot-Mix Asphalt Pavement. Unless otherwise specified by the OWNER, the existing hot-mix asphalt shall be cut back to produce a vertical edge for the full depth of the paving. The cut shall extend 24-in. back of the firm banks of the trench.

All courses of hot-mix asphalt pavement shall be of the types and classes as indicated on the plans. Thickness of each course shall match existing courses or meet the minimum thickness of each course of current OWNER standard for the street type. The joint formed at the interface of the existing pavement and the repair shall be sealed with a material approved by the OWNER.

402.4.6.1. Measurement for full depth Hot-Mix Asphalt Pavement. Hot-mix asphalt pavement shall be measured at the specified trench width plus 4-ft., thickness in inches, and the length measured in linear feet. Additional asphalt pavement ordered by the OWNER to be placed will be measured as the thickness in inches, and length and width in linear feet.

If paid for, crack sealer shall be measured as indicated on the plans.

402.4.7. Replacing Hot-Mix Asphalt Pavement on a Flexible Base. Unless otherwise specified by the OWNER, the existing hot-mix asphalt shall be sawed 24-in. back from the firm banks of the trench. The cut shall be replaced with a compacted flexible base, as specified in Item 301.5. Flexible Subbase or Base (Crushed Stone/Concrete), to match the existing thickness of the base, 6-in. minimum.

All courses of hot-mix asphalt pavement shall be of the types and classes as indicated on the plans.

402.4.7.1. Measurement for Hot-Mix Asphalt Pavement on a Flexible Base. Hot-mix asphalt pavement shall be 2-in. thick, specified ditch width plus 4-ft., and the length measured in linear feet. The flexible base shall be measured at the specified trench width only, 6-in. thick or the depth of the existing flexible base, and the length measured in linear feet.

402.4.8. Replacing One- or Two-Course Surface Treatment or Penetration Type Pavement. The pavement shall be replaced as specified by the OWNER in accordance with Item 404. Surface Treatments.

402.4.9. Replacing Gravel Pavement on a Dirt Base. The existing gravel pavement shall be replaced with compacted flexible base, as specified in Item 301.5. Flexible Subbase or Base (Crushed Stone/Concrete). The minimum thickness of flexible base shall be 8-in. unless otherwise specified by the OWNER.

402.4.9.1. Measurement. The flexible base shall be measured at specific trench width only, 8-in. thick, and the length measured in linear feet.

402.4.10. Payment for Pavement Replacement. If paid for by the OWNER, replacement curb, curb with gutter, sidewalks, drives, etc. shall be paid at the contract unit price per square-yard or linear feet as specified in the bid item, complete in place.

If paid for by the OWNER, replacement of pavement(s) and base(s) shall be paid at the contract unit price per square-yard of respective thickness, complete in place.

If paid for by the OWNER, replacement of one- or two-course surface treatment or penetration type pavement surface shall be paid in accordance with Item 404. Surface Treatments.

The contract unit price shall be total compensation for furnishing and placing all materials, including excavation, compaction, rolling and finishing, for disposal of all surplus material, and for all labor, tools, equipment and incidentals necessary to complete the work, all in accordance with the plans and specifications.

ITEM 404. SURFACE TREATMENTS

404.1. DESCRIPTION

This Item provides specifications for the construction and quality control required for the proper application of pavement surface treatments.

404.2. GERNERAL

404.2.1. Environmental Conditions. Surface treatments shall not be applied when the air temperature is below 60°F and is falling but may be applied when the air temperature is above 50°F and is rising, the air temperature being taken in the shade and away from artificial heat. If the air temperature does not meet these criteria, the OWNER shall evaluate the asphaltic material for applicability. Surface treatments shall not be applied when the temperature of the surface to which the surface treatment is to be applied is below 60°F. When latex modified asphalt cement is specified, surface treatments shall not be applied when the air temperature is below 80°F and is falling, but may be applied when the air temperature is above 70°F and is rising and shall not be applied when the temperature of the surface on which the surface treatment is to be applied is below 70°F. Asphaltic material shall not be placed when, in the opinion of the OWNER, general weather conditions are not suitable.

Slurry seal or micro-surfacing shall only be applied between March 1st and December 1st. Neither treatment shall be applied under any of the following conditions:

(1) In the period following precipitation with water remaining on the surface to be coated
(2) In foggy conditions
(3) If there is a threat of rain before the treatment can fully cure
(4) If there is danger that the finished product will freeze within 24-hours of application
(5) If weather conditions could delay opening to traffic beyond the time specified by the OWNER.

404.2.2. Storage and Stockpiling. Precautions shall be taken to insure aggregate does not become contaminated with over-sized rock, clay, silt or excessive amounts of moisture during storage. The stockpile shall be kept in areas that have good drainage. Segregation of aggregates proposed for use and as supplied to the mixing plant shall be avoided.

The CONTRACTOR shall be required to provide a suitable storage facility for all equipment and materials needed to perform the work. This site should be located as close as possible to the area of work being done to reduce turnaround time and insure an acceptable rate of work. The OWNER shall subject any site selected to final approval.

Temporary stockpiling of aggregates on the roadways shall be permitted, provided the stockpiles are spaced not less than 1,000-ft. apart and are so placed that they neither obstruct traffic nor interfere with roadway drainage. The CONTRACTOR shall be responsible for the proper preparation of all stockpile material necessary for protection of the aggregate and to prevent any contamination thereof.

404.3. SLURRY SEALS AND MICRO- (RE) SURFACING

The surface treatment 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.

404.3.1. Laboratory Evaluation. Before work commences, the CONTRACTOR shall submit a signed original of a mix design containing the test results and proportioning of the specific materials to be used on the project. A qualified laboratory must have performed this design. Previous lab reports covering the exact materials to be used may be accepted provided they were made during the calendar year. This initial mix design shall be done at the CONTRACTOR'S expense. Upon receipt of the original mix design, an independent qualified laboratory selected by the OWNER shall perform tests using the same materials as used in the initial mix design for verification of the results. This testing shall be done at the OWNER'S expense. No work shall begin until all materials and/or mix design proportions have met the specifications as required. Once the materials are approved, no substitution shall be permitted unless first tested and approved by the methods stated above.

404.3.2. Materials.

404.3.2.1. Mineral Filler. Mineral filler shall be a recognized brand of non-air-entrained Type I or II Portland that meets the requirements of ASTM D242 Mineral Filler For Bituminous Paving Mixtures, if required by the mix design. 0.5% to 2% by dry weight of aggregate shall be the range of mineral filler in the mix design. The mineral filler shall be considered as part of the dry aggregate.

404.3.2.2. Water. All water shall be potable and compatible with the slurry mix. The CONTRACTOR must insure compatibility. The percent of water in the mix design shall be as required to produce proper mix consistency.

404.3.2.3. Additives. The mix design laboratory as part of the mix design shall approve any additive used to accelerate or retard the break-set of the surface treatment materials. The amount and type of additive (if needed) shall be shown on the mix design and approved by the OWNER.

404.3.2.4. Aggregate. The mineral aggregate shall consist of natural or manufactured crushed stone such as granite, slag, limestone or other high quality aggregates or a combination thereof that conforms to the quality requirement of ASTM D1073 Fine Aggregate for Bituminous Paving Mixtures, and shall be free of dirt, organic matter, clay balls, adherent films of clay, dust or other objectionable material. If the OWNER accepts aggregate that is not free of dirt, organic matter, clay balls, adherent films of clay, or dust, the OWNER shall have the option to evaluate and accept or reject chemical modifiers of the asphaltic material. The aggregate shall contain no free water. Smooth textured sands of less than 1.25-percent water absorption shall not exceed 50-percent (by weight) of the total aggregate blend. For heavy-duty surface requirements, 100% crushed material is required.

The aggregate shall meet the gradations as shown in the Table 404.3.2.4.(a) Slurry Seal Aggregate Requirements or Table 404.3.2.4.(b) Micro-Surface Aggregate Requirements, as appropriate, and shall not vary from the low limit on one sieve to the high limit on the adjacent sieves or vice versa. The gradation type to be used shall be as designated by the OWNER.

Table 404.3.2.4.(a) Slurry Seal Aggregate Requirements

Sieve Size	Percent Passing
3/8-in.	100
No. 4	70-90
No. 8	45-70
No. 16	28-50
No. 30	19-34
No. 50	12-25
No. 100	7-8
No. 200	5-15

Table 404.3.2.4.(b) Micro-Surface Aggregate Requirements

Sieve Size	Percent Passing
3/8-in.	99-100
No. 4	86-94
No. 8	45-65
No. 16	25-46
No. 30	15-35
No. 50	10-25
No. 100	7-18
No. 200	5-15

404.3.2.5. Emulsified Asphalt. The asphalt emulsion shall be homogeneous and show no separation after mixing.

404.3.2.5.1. Slurry Seal. As directed by the OWNER, one of the following two grades of emulsion shall be selected. Grade CQS-1h (Quick Set) shall be specified on streets where the amount of time the street can be closed is restricted.

Grade SS-1h: Conforming to the requirements specified in ASTM D977 for Emulsified Asphalt.

Grade CQS-1h: Conforming to the requirements specified in ASTM D2397 for Cationic Emulsions (Quick Set).

Any emulsion used for slurry will be with 4% polymer modifier content based on bitumen weight, certified by the emulsion supplier, which shall be milled into the emulsion or blended into the asphalt prior to the emulsification process. It shall pass all applicable storage and settlement tests. The cement-mixing test shall be waived.

404.3.2.5.2. Micro-Surface. Emulsified asphalt for micro-surfacing shall be a quick-set polymer modified cationic type CSS-1h emulsion and conform to the requirements specified in AASHTO M208 and ASTM D2397 Cationic Emulsified Asphalt. It shall pass all applicable storage and settlement tests. A minimum of 3% polymer modifier content based on bitumen weight content, certified by the emulsion supplier, along with special quick-setting emulsifier agents, shall be milled into the asphalt emulsion. The cement mixing test shall be waived. The emulsified asphalt shall be so formulated that when the paving moisture is applied with the relative humidity at no more than 50% and ambient air temperature of at least 75°F, it will cure sufficiently such that rolling traffic can be allowed in one-hour with no damage to the surface.

404.3.2.6. Mixture Tests. Mixtures shall meet the requirements in Table 404.3.2.6.(a) Slurry Seal Mixture Requirements or Table 404.3.2.6.(b) Micro-Surface Mixture Requirements, as appropriate when tested by the given methods.

Table 404.3.2.6.(a) Slurry Seal Mixture Requirements

Characteristic	Test Method	Value
Consistency test	ASTM D3910 Standard Practices for Design, Testing, and Construction of Slurry Seal	2- to 3-cm Flow
Set time	ASTM D3910 (same as above)	12-hours maximum
Cure time	ASTM D3910 (same as above)	24-hours maximum
Wet stripping test	ISSA TB114	80%-coating minimum
Wet track abrasion test	ASTM D3910 (same as above)	75-g/ft^2 maximum

Table 404.3.2.6.(b) Micro-Surface Mixture Requirements

Characteristic	Test Method	Value
Set time	ASTM D6372 Standard Practice for Design, Testing, and Construction of Micro-Surfacing	12-hours maximum
Cure time	ASTM D6372 (same as above)	24-hours maximum
Wet stripping test	ISSA TB114	80%-coating minimum
Wet track abrasion test	ASTM D6372 (same as above)	75-g/ft^2 maximum
Marshall stability Flow units	ASTM D5581 Standard Test Method for Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus (6 inch-Diameter Specimen)	1800-lbs. minimum 6- to 16-units
Hveem stability, exceeding a height twice the maximum aggregate size	ASTM D1560 Resistance to Deformation and Cohesion of Bituminous Mixtures by Means of Hveem Apparatus	35 minimum
Set Time 30-minute Blotter test Displacement test Water resistance test @ 30-Minutes	ISSA TB102	 No Brown Stain No Displacement No Discoloration

404.3.3. Equipment. All methods and equipment employed in performing the work shall be subject to the approval of the OWNER before work is started and whenever found unsatisfactory they shall be changed and improved as required. All equipment must be maintained in a satisfactory condition.

The CONTRACTOR will provide suitable crack and pavement cleaning equipment, hand tools and any support equipment as necessary to perform the work.

404.3.3.1. Calibration. Each piece of equipment to be used shall be calibrated in the presence of the OWNER prior to construction. Previous calibration documentation covering the exact materials to be used may be accepted provided they were made during the calendar year. No machine will be allowed to work on the project until the calibration has been completed and/or accepted.

404.3.3.2. Verification. Test strips shall be laid (location to be determined by the OWNER) before construction begins. The OWNER will observe the test strip for verification or rejection according to the specifications. Upon failure of any test, additional test strips will be laid at no cost to the OWNER. The square-yards of the first test strip will be measured and paid for at the contract unit price.

A field test shall be made to check consistency of the surface treatment. If a line made through the surface treatment fills up, the mixture is too wet, which the CONTRACTOR shall correct. If the line stays, the slurry has a proper consistency.

404.3.3.3. Mixing Equipment.

404.3.3.3.1. Slurry Seal. The slurry seal mixing equipment shall be continuous flow mixing unit as to give a uniform and complete circulation of the batch in the mixer, so as not to segregate the aggregates, but will provide a thorough and uniform free flowing mix with the asphalt and water. The units shall be equipped with a water pressure system and nozzle type spray bar adequate for completely fogging the surface with 0.05- to 0.15-gallons-per-square-yard immediately ahead of the spreader box.

Application rate of aggregate, based on dry weight of aggregate, shall be 15- to 21-lbs-per-square-yard complete in place.

The residual asphalt content, based on % weight of dry aggregate, shall be 8% to 12%.

404.3.3.3.2. Micro-Surface Mixing Equipment. The material shall be mixed by a self-propelled micro-surfacing mixing machine which shall be a continuous flow mixing unit able to accurately deliver and proportion the aggregate, emulsified asphalt, mineral filler and water to a revolving multi-blade mixer and discharge the mixed product on a continuous flow basis. The machine shall have sufficient storage capacity for aggregate, emulsified asphalt, mineral filler and water to maintain an adequate supply to the proportioning controls. The machine shall be equipped with self-loading devices which provide for the loading of all materials while continuing to lay micro-surfacing, thereby minimizing construction joints.

Individual volume or weight controls for proportioning each material to be added to the mix shall be provided. Each material control device shall be calibrated and properly marked.

The mixing machine shall be equipped with a water pressure system and nozzle type spray bar to provide a water spray immediately ahead of and outside the spreader box with 0.05- to 0.15-gallons-per-square-yard.

The aggregate feed to the mixer shall be equipped with a revolution counter or similar device so the amount of aggregate used may be determined at any time. The mixing machine shall be equipped with an approved fines feeder that shall provide a uniform accurately metered, predetermined amount of the specified mineral filler. Application rate of aggregate, based on dry weight of aggregate, shall be 22- to 28-lbs-per-square-yard complete in place.

The emulsion pump shall be a positive displacement type and shall be equipped with a revolution counter or similar device so that the amount of emulsion used may be determined at any time. The residual asphalt content, based on % weight of dry aggregate, shall be 6% to 11.5%.

404.3.3.4. Spreading Equipment.

404.3.3.4.1. Slurry Seal. The spreader box shall be equipped to prevent loss of slurry seal from all sides and with a flexible rear strike-off capable of being adjusted. It shall have suitable means for side tracking to compensate for deviations in pavement geometry. The box shall be kept free of built-up asphalt and aggregate. The strike-off drag shall be kept completely flexible at all times.

404.3.3.4.2. Micro-Surface. The surface mixture shall be spread uniformly by means of a mechanical type spreader box attached to the mixer, equipped with paddles to agitate and spread the materials throughout the box. A front seal shall be provided to insure no loss of the mixture at the road contact point. The rear seal shall act as final strike off and shall be adjustable. The mixture shall be spread to fill cracks and minor surface irregularities and leave a uniform skid resistant application of material on the pavement. The longitudinal joint where two passes join shall be neat appearing, uniform and lapped. All excess material shall be removed from the job site prior to opening the road. The spreader box shall have suitable means provided to side shift the box to compensate for variations in pavement geometry.

404.3.4. Preparation. Any breakdowns, base failures, or other defects shall be properly repaired by the OWNER before application of the surface treatment. No work shall commence on any location until approval by the OWNER.

Immediately prior to applying the surface treatment, CONTRACTOR shall thoroughly clean the pavement of all loose materials, vegetation, soil and objectionable material. The CONTRACTOR shall cover manholes, valve boxes, raised pavement markers and other designated objects to insure their integrity. All pavement cleaning and covering of appurtenances shall be subject to the final approval and acceptance of the OWNER.

If required, the CONTRACTOR shall apply a tack coat or a second coverage of treatment on brick, concrete, or other highly absorbent or polished pavements. If a tack coat is required, a 1-part emulsion, 3-part water tack coat of the same asphalt emulsion type and grade as specified for the surface treatment is required. Rate of application of tack coat material shall be 0.05- to 0.10-gallons-per-square-yard. All debris and unused material shall be removed.

404.3.5. Surface Treatment Application. Surface treatments shall be placed on the location and within the time limit as specified by the OWNER.

404.3.5.1. Fogging. If conditions require, the pavement shall be pre-wetted by fogging ahead of the slurry/spreader box. Water used in fogging the surface shall be applied so that the entire surface is damp with no flowing water in front of the box. Rate of spray shall be 0.05- to 0.15-gallons-per-square-yard or as directed by the OWNER. No streaks, lumps, balls or unmixed aggregated shall be permitted.

404.3.5.2. Mix Stability. The mix shall be sufficiently stable during the spreading period so that the emulsion does not break, there is no segregation of the fines from the coarser aggregate and the liquid of the mix does not float to the surface.

404.3.5.3. Lines and Joints. Straight lines along curb gutters and shoulder will be required. No runoff on these areas will be permitted. Lines at intersections must be kept straight to provide a good appearance. Surface treatment shall be placed at the lip of the gutter or at a distance from the face of the curb as directed by the OWNER.

No excessive buildup or unsightly appearance shall be permitted on longitudinal or transverse joint. An excessive overlap will not be permitted on longitudinal joints. The CONTRACTOR shall provide suitable width spreading equipment to produce a minimum number of longitudinal joints throughout the project. Longitudinal joints shall be placed on lane lines when possible. If half passes are used, they shall not be the last passes on any paved area.

404.3.5.4. Rolling. If required, specified areas shall be rolled by a self-propelled 10-ton pneumatic roller with tire pressure of 50-psi and equipped with a water spray system. The slurried pavement shall be subjected to a minimum of 5 full coverages by the roller. Rolling should not commence until the slurry has cured enough so that it will not pick up on the tires. In areas of high traffic volume and subject to slow turning, e.g. major intersections, rolling may be feasible.

404.3.5.5. Hand Work. In areas where the spreader box cannot be used, hand squeegees to provide complete and uniform coverage shall apply the surface treatment. Any joint cracks not filled by the mix shall be corrected by use of hand squeegees. Handwork shall be completed during the machine applying process. Due to the difficulty in hand working micro-surfacing material because of the quick-set nature of the emulsion, hand work for micro-surface treatment shall be kept to a minimum.

404.3.5.6. Curing and Finishing. All traffic shall be kept off the treated area until it has cured to a firm condition that will prevent damage to the surface treatment. Any uncured areas damaged will be repaired satisfactory to the OWNER at the CONTRACTOR'S expense.

After completion of surface treatment placement, the CONTRACTOR shall remove covered objects (manhole covers, valve covers, raised traffic markers, etc.) so the object protected will remain fully functional. All objects not to have been covered shall be restored to original integrity. Any objects damaged by the CONTRACTOR'S work activities shall be repaired or replaced at no cost to the OWNER.

Any work directed by the OWNER to correct any appearance defect shall be subject to the final approval of the OWNER.

The CONTRACTOR shall remove all unused material and debris from the site prior to final acceptance.

404.3.6. Measurement and Payment. The treated area on each street shall be field measured and calculated in square-yards. Payment shall be approved if the amount of emulsion and aggregate fall within the specified application range per square-yard. Payment per square-yard shall be full compensation for grass removal, cleaning the existing pavement, all material (including mineral filler, water, modifiers and additives) labor, tools, equipment, maintenance of traffic and notification of adjacent property owners and incidentals necessary to complete the work.

404.4. BITUMINOUS SURFACE TREATMENT (CHIP SEAL)

404.4.1. Description. This item shall consist of a wearing surface composed of one, two or three applications of asphaltic materials, each covered with aggregate, constructed on the prepared base course or surface in accordance with the requirements as shown on the plans and these specifications.

404.4.2. Materials.

404.4.2.1. Asphaltic Materials. The asphaltic materials used shall be of the type and grade as specified by the owner and shall meet the requirements of Item 302.3. Bituminous Materials.

WARNING TO CONTRACTOR: Attention is called to the fact that asphaltic materials are highly flammable. The utmost care shall be taken to prevent open flames from coming in contact with the asphaltic materials or the gases of same. The CONTRACTOR shall be responsible for any fires or accidents that may result from heating the asphaltic materials.

404.4.2.2. Aggregate. Aggregate shall be composed of dry, sound, durable particles of processed stone or steel slag having a percent of wear of not more than 35 when tested in accordance with ASTM C131 Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine. Crushed gravel shall not be allowed. The aggregate shall be free from organic matter, clay, loam, or coated pebbles and shall contain no more than five-percent of slate, shale, schist, or soft particles.

The aggregate used shall be of the type and grade or types and grades selected from those prescribed in Item 301.5. Flexible Subbase or Base (Crushed Stone/Concrete). The particular type and grade or types and grades shall be as provided on the plans or as required by the OWNER.

Aggregate when tested by standard laboratory methods shall meet the grading requirements in Table 404.4.2.2.(a) Chip Seal Aggregate Gradations. Prior to shipping aggregate to the project, the CONTRACTOR shall furnish the OWNER with samples of the proposed aggregate.

Table 404.4.2.2.(a) Chip Seal Aggregate Gradations

Sieve Size	% Retained, by weight	Sieve Size	% Retained, by weight
FIRST APPLICATION			
Small Aggregate "SB"		**Large Aggregate "LB"**	
5/8-in.	0%	1-in.	0%
1/2-in.	0 - 10%	3/4-in.	15 - 45%
1/4-in.	70 - 100%	1/2-in.	85 - 100%
No. 10	95 - 100%	1/4-in.	98 - 100%
SECOND APPLICATION			
Small Aggregate "ST"		**Large Aggregate "LT"**	
3/8-in.	0%	3/4-in.	0%
1/4-in.	2 - 20%	1/2-in.	0 - 10%
No. 10	70 - 100%	1/4-in.	65 - 85%
No. 20	95 - 100%	No. 10	90 - 100%
		No. 20	98 - 100%

404.4.2.2.1. Precoated Aggregate. The grade of aggregate specified shall meet all other requirements of Item 404.4.2.2. Aggregate prior to the application of precoat or fluxing material. Materials that are not uniformly and/or properly coated, in the opinion of the OWNER, shall not be accepted for use.

Precoated aggregate shall be aggregate of the type and grade specified, coated with 0.5- to 1.5-percent (by weight) of residual bitumen from a precoating material. When limestone rock asphalt is used, it shall be fluxed with 0.5- to 1.5-percent (by weight) of fluxing material. The materials may be mixed on the job or at a central mixing plant and shipped ready for use. Mixes that do not maintain flow qualities such that the precoated aggregate may be satisfactorily spread by approved mechanical spreading devices will not be acceptable.

Precoated aggregate will show no stripping when tested in accordance with TxDOT test method Tex-530-C Effect of Water on Bituminous Paving Mixtures. If antistripping additives are required to meet this requirement, they shall meet the requirements of TxDOT Item 301 Asphalt Antistripping Agents.

404.4.3. Construction Methods.

404.4.3.1. Equipment and Preparation. All storage tanks, piping, retorts, booster tanks, and distributors used in storing or handling asphalt shall be kept clean and in good operating condition at all times. They shall be operated in such a manner that there shall be no contamination of the asphalt with foreign material.

The area to be treated shall be cleaned of dirt, dust or other deleterious matter by sweeping or other approved methods. If it is found necessary by the OWNER, the surface shall be lightly sprinkled just prior to the application of the asphaltic material.

404.4.3.2. Application of Asphalt. The OWNER shall select the temperature of application based on the temperature-viscosity relationship that shall permit application of the asphalt with the limits recommended in Item 302.5. Storage, Heating and Application Temperature of Bituminous Materials. The CONTRACTOR shall apply the asphalt at a temperature within 15°F of the temperature selected. It shall be the responsibility of the CONTRACTOR to provide and maintain in good working order a recording thermometer at the storage heating unit at all times.

Asphaltic material may be placed by preheating aggregate to 280°F when the air temperature is 70°F and falling or when the air temperature is 50°F and rising.

Asphaltic material of the type and grade shown on the plans shall be applied on the clean surface by an approved type of self-propelled pressure distributor so operated as to distribute the material in the quantity specified, evenly and smoothly, under a pressure necessary for proper distribution. The CONTRACTOR shall provide all necessary facilities for determining the temperature of the asphaltic materials in all of the heating equipment and in the distributor, for determining the rate at which they are

applied, and for securing uniformity at the junction of two distributor loads. The distributor shall have been recently calibrated and the OWNER shall be furnished an accurate and satisfactory record of such calibration. After beginning the work, should the yield on the asphaltic materials appear to be in error, the distributor shall be recalibrated in a manner satisfactory to the OWNER before proceeding with the work.

Asphaltic materials for each course may be applied for the full width of the surface treatment in one application, unless the width exceeds 26-ft. No traffic or hauling shall be permitted over the freshly applied asphaltic materials. Asphaltic materials shall not be applied until immediate covering with aggregate is assured.

404.4.3.3. Application of Aggregate. Aggregate, of the type and grade shown on the plans for the first course, shall be immediately and uniformly applied and spread by approved calibrated mechanical spreaders, operated on the rear of the aggregate trucks or as a separate power-driving unit. These spreader units shall be approved by the OWNER prior to the start of the work. The aggregate shall be applied at the approximate rates indicated on the plans, within the limits shown in Table 404.4.3.4.(a) Chip Seal Rates of Application, and as directed by the OWNER. The entire surface shall then be broomed, bladed or raked as required by the OWNER and shall be thoroughly rolled with both pneumatic tire and steel wheel (3- to 6-tons) rollers to insure proper embedding into the bitumen. The rolling shall be continued until no more aggregate can be worked into the surface. Rolling shall meet the governing specifications for Item 301.1.2. Rolling of Embankment, Subgrade or Flexible Base.

404.4.3.4. Rates of Application. The asphalt and aggregates shall be applied at the approximate rates indicated on the plans within the following limits, as directed by the OWNER. The rates of application and the estimated quantities of aggregate are based on the usual or average gradation of known materials. Prior to shipping aggregate to the project, the CONTRACTOR shall furnish the OWNER with samples of the proposed aggregate so that the gradation may be determined and rate of application changed if necessary.

Table 404.4.3.4.(a) Chip Seal Rates of Application

Application	Asphalt gal/yd^2		Aggregate yd^3 per yd^2	
	Minimum	Maximum	Minimum	Maximum
SMALLER AGGREGATE				
First, Aggregate “SB”	0.20	0.30	1:100	1:75
Second, Aggregate “ST”	0.30	0.40	1:200	1:150
LARGER AGGREGATE				
First, Aggregate “LB”	0.25	0.35	1:75	1:50
Second, Aggregate “LT”	0.35	0.45	1:150	1:100

404.4.3.5. Multiple Courses. Where double or triple surface courses are specified on the plans, each succeeding course shall be constructed by the procedures as prescribed for the first course. The rates of asphaltic material and aggregate for multiple-course construction shall be as shown on the plans within the limits shown in Table 404.4.3.4.(a) Chip Seal Rates of Application or as directed by the OWNER.

404.4.3.6. Maintenance and Completion. The CONTRACTOR shall be responsible for the maintenance of the surface and distribution of the excess aggregate until final completion and acceptance of the entire project by the OWNER. All holes or failures in the surface shall be repaired per each course by use of additional asphalt and aggregate. All fat or bleeding surfaces shall be covered with approved cover material per each course in such a manner that the asphaltic material will not adhere to or be picked up by the wheels of vehicles.

404.4.4. Measruement and Payment. Bituminous surface treatments shall be measured by the square-yard of surface area of completed and accepted per bid item “One-, “Two-, or “Three-Course Surface Treatment.”

Rolling shall not be measured for payment but shall be considered as subsidiary to the Items of “Asphalt” and/or “Aggregate.” Work performed and materials furnished as prescribed by this item and measured as provided in this item shall be paid for at the unit price bid for “One-, “Two-, or “Three-Course Surface Treatment,” which price shall be full compensation for cleaning and sprinkling the surface to be treated; for furnishing, preparing, hauling and placing all materials; for all blading, brooming, rolling; and for all manipulations, labor, tools, equipment and incidentals necessary to complete the work.

ITEM 501. UNDERGROUND CONDUIT MATERIALS

501.1. GENERAL

All pipe and fittings shall be new.

The OWNER shall at all times have free access to the manufacturer's plant while production is in progress, and may at any time refuse to accept pipe made when the plant is failing to follow the stipulations of the specifications in regard to workmanship, or failing in provisions to insure a uniform product coming within the permissible variations of the specifications. The OWNER may reject pipe if adequate means and methods are not provided so as to insure the manufacture of a product of uniform high quality.

Pipe shall be color coded according to the American Public Works Association Uniform Color Code (i.e. blue for water, green for wastewater or storm drain lines, violet for reclaimed water, etc.) or labeled with labeling tape identifying its specific use. Where feasible, permanent identification of the piping service shall be provided by co-extruding color stripes into the pipe outside surface. The striping shall be of the same material except for the color. For co-extruded markings, IPS sized pipe shall have four equally spaced, longitudinal color stripes and DIPS sized pipe shall have three equally spaced pairs of longitudinal color stripes. The color or marking shall be visible on top of buried pipe when pipe is excavated.

Pipe shall be acceptable by the Underwriters' Laboratories, Inc. or Factory Mutual Research when specifically requested and shall be acceptable by the State Fire Insurance Commission for use in water distribution systems when used for fire protection without penalty. Potable water pipe shall also bear the seal of approval (or "NSF" mark) of the National Sanitation Foundation Testing Laboratory for potable water pipe.

Installation shall be performed in accordance with relevant portions of Division 500 Underground Conduit Construction and Appurtenances.

501.1.1. Rejection. Pipe, joints, fittings, or coatings may be rejected for failure to meet any of the requirements of this specification or for any manufacturing, transportation and/or handling defects that may cause pipe, joints, fittings or coatings to be unsuitable for intended use(s). When approved by the OWNER, materials may be re-tested to establish conformity. All rejected materials shall be plainly marked by the Engineer and shall be replaced by the CONTRACTOR with materials which meets the requirements of these specifications. Such rejected materials shall be removed immediately from the site of the work.

501.1.2. Damaged Pipe. Pipe that is damaged during installation will be repaired only by a method approved by the OWNER. If, in the opinion of the OWNER, a satisfactory repair cannot be made by the method(s) suggested by the CONTRACTOR or pipe manufacturer, the damaged pipe shall be removed and replaced with sound pipe that meets the specifications of the contract. Repairs or replacement will be at no cost to the OWNER including costs associated with removing and replacing non-damaged pipe for the purpose of removing damaged pipe.

501.2. CLAY WASTEWATER PIPE.

501.2.1. General. Clay wastewater pipe shall conform to ASTM C700 Vitrified Clay Pipe, Extra Strength, Standard Strength, and Perforated, having compression joints and bell and spigot ends or compression couplings for plain-end pipe.

501.2.2. Class. Extra strength vitrified clay wastewater pipe shall be used unless otherwise designated.

501.2.3. Fittings. Fittings shall be of the same test strength as the pipe as ordered or shown on plans.

501.2.4. Joints. Factory-fabricated compression joints and joints for fittings shall meet the requirements of ASTM C425 Compression Joints for Vitrified Clay Pipe and Fittings.

501.2.5. Pipe Tests. Tests of the pipe shall be made in accordance with ASTM C301 Test Methods for Vitrified Clay Pipe.

501.3. VITRIFIED CLAY PIPE USED IN TRENCHLESS APPLICATIONS

501.3.1. General. Clay pipe used for microtunneling, sliplining, pipe bursting, and tunnels shall conform to ASTM C1208 (C1208M) Vitrified Clay Pipe and Joints for Use in Microtunneling, Sliplining, Pipe Bursting, and Tunnels. The pipe shall have a minimum compressive strength of 7000-psi.

501.3.2. Pipe Joints. The pipe joint collar shall be manufactured of Series 316 stainless steel or better and compression discs are required to distribute the jacking forces.

501.3.3. Pipe Tests. Tests of the pipe shall be made in accordance with ASTM C1208 (C1208M).

501.4. CONCRETE PRESSURE PIPE AND FITTINGS

501.4.1. General. These specifications cover the manufacture of concrete pressure pipe designed for internal pressures from a minimum of 20-psi to a maximum of 350-psi. Products shall conform to relevant standards as noted in Table 501.4.1.(a) Standards for Concrete Pressure Pipe and Fittings.

Table 501.4.1.(a) Standards for Concrete Pressure Pipe and Fittings

Item Reference No.	AWWA Standard	Description
501.4.5	C301	Prestressed Concrete Pressure Pipe, Steel-Cylinder Type
	C304	Design of Prestressed Concrete Cylinder Pipe
501.4.6	C303	Bar-Wrapped Concrete Cylinder Pipe

Items 501.4.2. through 501.4.4., inclusive, shall apply to each type of pipe in Item 501.4 Concrete Pressure Pipe and Fittings. Concrete Pressure Pipe and Fittings shall be provided in accordance with ANSI/AWWA C301. In accordance with C301, Section III.A – Purchaser Options and Alternatives, the purchasers are advised that, while the standard presents information on materials and procedures for manufacture of the pipe, it may not contain all of the engineering information needed to prepare a complete specification for a particular pipeline installation. A specific pipeline installation may require provisions more restrictive than those in the standard and will likely require additional design and installation details.

Reference to AWWA Manual M9 - Concrete Pressure Pipe, should be considered as a supplement to the use of the C301 standard, and information in the manual should not be regarded as superseding any portion of the C301 standard. Purchaser options and alternatives shall be provided by the specifier, including working pressure, surge pressure, field-test pressure, external loading conditions, method of bedding and backfilling, manner of storage and delivery (if required by the manufacturer), tabulated layout schedules, and detailed shop drawings and schedules submitted to the OWNER for review. Purchaser options and alternatives shall be specified in the supplemental conditions, plans, or technical specifications.

The type of pipe to be supplied shall be as shown on the plan and/or in the special provisions for each project.

The manufacturer shall submit a successful experience record in the design and construction of the type of concrete pressure pipe involved. Each type of pipe shall have the complete approval of the Underwriters' Laboratories, Inc., for the manufacture of the pipe specified and diameters required. Pipe shall have NSF61 standard approval for potable water applications.

Upon award of the Contract, the CONTRACTOR shall furnish OWNER with shop drawings showing the pipe and fittings to be furnished and shall include a tabulated layout schedule with reference to the stationing of the contract drawings with plan and profile drawings. Such drawings shall be subject to the approval of the OWNER and fabrication of pipe and fittings shall not be commenced until such drawings have been approved by the OWNER. Such approval by the OWNER shall not relieve the CONTRACTOR of any responsibility of providing pipe and/or fittings in accordance with the OWNER'S plans and specifications.

No cracks will be permitted in the mortar lining of the pipe, except for minor hairline cracks. Pipe with cracks through the mortar wall or damaged bells, spigots or joint grooves shall not be accepted without manufacturer-approved repair. Cracks in the vicinity of the spigot of the pipe and those cracks in the vicinity of the circumferential wrappers and outlets shall not be allowed. Cracks up to 0.010-in in the lining of the pipe are acceptable if they are not excessive in length (should be less than 2 ft.).

All cracks to the mortar coating shall be repaired according to the manufacturer's specification prior to installation.

501.4.2. Fittings and Specials. The manufacturer shall furnish all fittings and special pieces required for closures, bends, branches, manholes, air valves, blow offs and connections to mainline valves and other fittings shown on the contract drawings or as set out in the specifications conforming with AWWA C301,

AWWA C303, or AWWA C304 as applicable. All openings in the pipe for fittings, manholes, taps, blow offs, etc. shall have the interior and exterior surfaces of the steel lined and coated with mortar. The lining thickness shall be a minimum of 0.5-inches for sizes 16-in. and smaller, and 0.75-in. minimum lining thickness for sizes larger than 16-in. The minimum coating thickness shall be 1-in. The type of fittings and details covering the design of fittings and specials shall be furnished by the manufacturer and subject to the approval of the OWNER. The fittings and specials shall comply in all respects with the requirements of AWWA with modifications as herein set forth.

501.4.3. Flanged Outlets. Flanged outlets shall be insulated at all points where external valves, pipe, fittings, etc., are connected to the line. The CONTRACTOR shall furnish an insulating flange kit, flange gaskets, insulating sleeves, and two plastic washers for each bolt approved by the OWNER. Bolts, nuts, and washers for flanged outlet connections shall be carbon steel.

501.4.4. Tests. All pipe shall be tested in accordance with applicable specifications and AWWA Standards. In addition to certification of all applicable tests required by governing AWWA Standards, the following tests or certifications of tests may be required.

501.4.4.1. Steel Cylinder Pipe. The manufacturer shall submit for approval the specified details of materials and methods of welding it proposes to use before any welding is done.

The manufacturer shall furnish one specimen for tensile tests of welds from each 3,000-ft. of pipe. If tests indicate the welding is unsatisfactory, additional samples as required shall be furnished. Two test cylinders out of each day's pour of the concrete used, or as required by the OWNER, shall be furnished for testing by an independent laboratory. The cost of such a test shall be borne by the OWNER. Certified test reports made by the manufacturer shall be acceptable in lieu of the test cylinders, provided such test certificates show that they cover pours from which the purchased pipe is made.

Mill test reports on each heat from which steel cylinders and reinforcing are rolled shall be furnished by the OWNER, if required.

Test certificates showing the physical properties of the compound used in the gaskets shall be furnished by the OWNER, if required.

501.4.4.2. Three-Edge Bearing Test. The manufacturer of concrete cylinder pipe supplied in accordance with the provisions of Item 501.4. Concrete Pressure Pipe and Fittings shall have demonstrated, or shall demonstrate as may be required, that the pipe when tested in a three-edge bearing test as described in ASTM C497 (C497M) Concrete Pipe, Sections or Tile under a load equivalent to the design ditch load shall not deflect more than 0.1-percent. At the above specified load, there shall be no continuous cracks wider than 0.002-in. for a length of 12-in.

501.4.5. Prestressed Concrete Cylinder Pipe, AWWA C301.

501.4.5.1. General. The pipe shall comply in all respects with the requirements of AWWA C301 Prestressed Concrete Pressure Pipe, Steel Cylinder Type, for Water and Other Liquids. The pipe may be of two types of prestressed concrete steel cylinder pipe as specified on the plans and/or specifications or special conditions:

(1) the lined cylinder type with a core composed of a steel cylinder lined with concrete and subsequently wire-wrapped directly on the steel cylinder and coated with the mortar.
(2) the embedded cylinder type with a core composed of a steel cylinder encased in concrete and subsequently wire-wrapped on the exterior concrete surface and coated with concrete or mortar.

501.4.5.2. Design Pressures and Stresses. Design pressure shall be that shown on plans and/or specifications. The size of the high-tensile wire and the spacing and tension under which it is wound shall be such that the conditions required by AWWA C304 Design of Prestressed Concrete Cylinder Pipe are met.

501.4.6. Bar-Wrapped Concrete Cylinder Pipe, AWWA C303.

501.4.6.1. General. The pipe shall consist of a welded sheet-steel or plate-steel cylinder, manufactured by the spiral or straight seam method with joint rings attached, inside of which a cement mortar lining is centrifugally spun; a mild steel bar spirally wrapped under measured tension on the steel cylinder and protective cement mortar coating applied to the outside of the cylinder and spirally-wrapped rod.

The manufacturer shall furnish pipe in uniform lengths except lengths ordered as specials.

The pipe shall comply in all respects with the requirements of AWWA C303, with the following addition.

501.4.6.2. Design Pressures and Stresses. Design pressure shall be that shown on the plans and/or specifications. Steel cylinder and bar reinforcement shall be designed in accordance with AWWA Manual M9, Concrete Pressure Pipe.

501.5. REINFORCED CONCRETE WASTEWATER PIPE WITH RUBBER GASKET JOINTS

501.5.1. General. Except as applicable to Item 501.5.2. Alternate Concrete Pipe D-Load Design, reinforced concrete pipe manufactured under these specifications shall conform to ASTM C76 (C76M) Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe; or ASTM C655 (C655M) Reinforced Concrete D-Load Culvert, Storm Drain, and Sewer Pipe, and by a plant certified by the American Concrete Pipe Association, Texas Department of Transportation, or other recognized authority, with the following additions:

(1) All pipe shall be machine made by a process which shall provide for uniform placement of zero slump concrete in the form and compaction by mechanical devices which shall assure a dense concrete in the finished product.
(2) Aggregates for the concrete shall comply with requirements ASTM C33 Concrete Aggregates, with the additional requirement that the aggregate shall have a minimum of 50-percent of calcium carbonate equivalent.
(3) Pipe furnished under this specification shall be steam cured in accordance with methods prescribed in ASTM C76 (C76M) Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe except that the steam curing time shall be not less than eight-continuous-hours.
(4) The pipe and connecting joints shall be subject to the hydrostatic tests set forth in ASTM C443 (C443M) Joints for Concrete Pipe and Manholes, Using Rubber Gaskets, both for pipes in straight alignment and for pipes in maximum deflected position without leakage either in the pipe or in the joints.

501.5.2. Alternate Concrete Pipe D-Load Design. When bedding is specified in accordance with Item 504.5.2.16. Alternate Embedment for Concrete Pipe, reinforced concrete pipe shall conform to ASTM C1417 (C1417M) Manufacture of Reinforced Concrete Sewer, Storm Drain, and Culvert Pipe for Direct Design. This specification covers the manufacture and acceptance of precast concrete pipe designed to conform to the OWNER's design requirements and to ASCE 15-93, ASTM C655 (C655M) Specification for Reinforced Concrete D-Load Culvert, Storm Drain, and Sewer Pipe, or an equivalent design specification. Conditions 501.5.1. (1) through (4) apply to pipe provided under this specification and appropriate corrosion protection shall be furnished for pipe used in wastewater applications.

501.5.3. Steel Reinforcement. All steel reinforcement shall be in accordance with ASTM C76 (C76M) Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe and shall be circular in shape. No elliptical reinforcement shall be permitted. Where Class III pipe of sizes larger than 30-in. in diameter are specified, the manufacturer may, at its option, furnish pipe manufactured with either Wall "B" or Wall "C" minimum thicknesses, and the applicable minimum steel area as listed for circular cages in Table II of ASTM C76 may be substituted, at the manufacturer's option, for those listed in Table III of ASTM C76, provided test strength requirements for Class III pipe are satisfactorily met.

Where Class IV or V pipe is specified, the steel as called for in the wall as designated shall be furnished. Quadrant reinforcement shall be acceptable. As an alternate the pipe may be designed as detailed in ASTM C655 (C655M) Reinforced Concrete D-Load Culvert, Storm Drain, and Sewer Pipe. Proof of design must be submitted.

501.5.4. Joints. Connecting joints shall be made using a flexible watertight rubber-type compression gasket. The rubber gasket shall be the sole element of the joint depended upon to provide water tightness.

501.5.4.1. Rubber Gaskets. All rubber-type gaskets shall be of the round profile design. The rubber gasket shall be required to meet and be tested in accordance with ASTM C443 (C443M) Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets.

501.5.4.2. Deflection. The joint design shall provide for the deflection of a pipe unit by opening one side of the outside perimeter of the joint ½-inch wider than the full "home" position without reducing its

water tightness. Where greater deflections are required that provided by the joint design, beveled joints or elbows shall be provided.

501.5.4.3. Joint Approval. A detailed design of the joint or joints, including design and durometer hardness of the rubber gasket proposed to be furnished under this specification, shall be approved by the OWNER prior to installation. The design shall also include minimum and maximum interior joint opening in the assembled position in straight alignment and the maximum interior joint opening in the maximum deflected position. Joint dimensions (waste bell and spigot) should be addressed in shop drawings.

501.5.5. Fittings and Specials. Component parts for all specials such as bends, wyes, tees, etc. shall be manufactured on machines and in the same manner as straight joint concrete wastewater pipe under these specifications, except that joint lengths may be shorter than minimum listed.

501.5.6. Coatings and Linings. Coatings and liners called for in the specifications or as indicated on the plans shall meet the requirements of Item 502.9. Corrosion-Resistant Coatings and Liners for Wastewater Conduit and Appurtenances and shall be installed or applied by the pipe manufacturer.

501.5.7. Repairs. Repairs shall be permitted as set out in ASTM C76 and/or ASTM C655 except field repairs shall be permitted only with prior approval of the OWNER. Repairs to pipe and shall be done in strict conformity with all applicable specifications, instructions and recommendations of the manufacturer to ensure material warranty. If, in the opinion of the OWNER, repairs should not be made, the section of pipe shall be rejected and removed from the construction site and not repaired or returned to any of the OWNER'S projects. Rejected pipe shall be marked in a manner mutually agreed upon by the OWNER and the pipe manufacturer.

Field repairs on damage to the gasket bearing area shall not be allowed without prior approval of the OWNER.

501.5.8. Markings. Each length of pipe shall bear the initials or name of the person, company or corporation by whom it was manufactured; date of manufacture; and the class of pipe. The markings shall be indented or stenciled on the exterior or interior of the barrel near the bell and shall be plainly legible for purpose of identification.

501.5.9. Tests. The pipe shall be required to meet and be tested in accordance with ASTM C76 (C76M) Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe, or ASTM C655 (C655M) Reinforced Concrete D-Load Culvert, Storm Drain, and Sewer Pipe, as applicable.

The connecting joints shall be subject to the hydrostatic tests set forth in ASTM C443 (C443M) Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets.

The rubber gasket shall be required to meet and be tested in accordance with ASTM C443 (C443M).

501.5.10. Rejection. The pipe may be rejected for having defects or failure to meet the requirements as follows:

(1) variations in any dimension exceeding the permissible variations prescribed,
(2) a piece broken out of the bell or spigot or tongue or groove end of such size that the water tightness of the joint should be impaired,
(3) a shattering or flaking of concrete or other conditions indicating an improper concrete mix,
(4) lack of uniformity in placement of steel which might preclude all joints being typical of those tested,
(5) cracks sufficient to impair the strength, durability or serviceability of the pipe,
(6) failure to conform with any of the specifications herein set forth or referenced,
(7) the complete absence of distinct web-like markings, which may be indicative of a deficiency of water in the concrete mix, from the external surface of the pipe made by any process in which the forms are removed immediately after the concrete has been placed, unless specimens submitted for test that do not have such web-like markings shall have passed the physical tests required by these specifications,
(8) failure of pipe to go completely "home" due to binding of spigot against bell or tongue against groove,
(9) failure to pass any of the tests in Item 501.5.9. Tests,
(10) joint sections with spalls, cracks, fractures, or other imperfections that could adversely affect the performance of the joint,
(11) failure to meet the requirements for coatings and linings.

501.6. REINFORCED CONCRETE CULVERT, STORM DRAIN, PIPE AND BOX SECTION

This item shall govern reinforced concrete culvert, storm drain, pipe and precast reinforced concrete box sections. Pipe shall be cured in accordance with the applicable ASTM Designations for each type of pipe as referred to below.

501.6.1. Reinforced Concrete Culvert, Storm Drain, and Pipe.

501.6.1.1. General. Except as applicable to Item 501.6.1.1.1. Alternate Concrete Pipe D-Load Design, circular reinforced concrete pipe shall conform to ASTM C76 (C76M) Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe; arch pipe shall conform to ASTM C506 Reinforced Concrete Arch Culvert, Storm Drain, and Sewer Pipe; elliptical pipe shall conform to ASTM C507 Reinforced Concrete Elliptical Culvert, Storm Drain, and Sewer Pipe, of the class as designed on the plans subject to the following modifications:

(1) All pipe shall be machine-made by a process which shall provide for uniform placement of zero slump concrete in the form and compaction by mechanical devices which shall assure a dense concrete in the finished product.
(2) Sizes larger than 60-in. diameter shall be manufactured using two lines of circular reinforcement.
(3) Where Class III pipe of sizes larger than 60-in. diameter are specified, the manufacturer may at its option furnish pipe manufactured with either Wall "B" or Wall "C" minimum thicknesses and the applicable minimum steel area as listed for circular cages in Table II of ASTM C76 (C76M), provided tests strength requirements for Class III pipe are satisfactorily met.

501.6.1.1.1. Alternate Concrete Pipe D-Load Design. When bedding is specified in accordance with Item 504.5.2.16. Alternate Embedment for Concrete Pipe, reinforced concrete pipe shall conform to ASTM C1417 (C1417M) Manufacture of Reinforced Concrete Sewer, Storm Drain, and Culvert Pipe for Direct Design. This specification covers the manufacture and acceptance of precast concrete pipe designed to conform to the OWNER's design requirements and to ASCE 15-93, ASTM C655 (C655M) Specification for Reinforced Concrete D-Load Culvert, Storm Drain, and Sewer Pipe, or an equivalent design specification. Conditions of 501.6.1.1. modifications (1) and (2) apply to pipe provided under this specification.

501.6.1.2. Sizes and Permissible Variations. Variations in diameter, size, shape, wall thickness, reinforcement, placement of reinforcement, laying length and the permissible underrun of length shall be in accordance with the applicable ASTM specification for each type of pipe as referred to previously.

Where rubber gasket pipe joints are to be used, the design of joints and permissible variations in dimensions shall be in accordance with ASTM C443 Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets, Sections 5 and 6.

501.6.1.3. Joints. Pipe to be placed along curves shall consist of whatever pipe joint lengths or beveled end joints of pipe or combination thereof that are required to place the pipe on the designated centerline curve with no more than one-half of the tongue length of the pipe exposed from its normal fully closed joint position.

501.6.1.3.1. Flexible Joint Sealant. Unless otherwise specified on the plans or in the special provisions, pipe joints shall be sealed with one of the following types of gaskets; Flexible Joint Sealant manufactured in accordance with ASTM C990, Expanded Cellular Rubber Gaskets in accordance with ASTM D1056 Flexible Cellular Materials – Sponge or Expanded Rubber, Class 2C1, or Elastomeric Seals. Each joint shall require one continuous gasket conforming to the joint shape. Gasket cross-sectional diameters shall be in accordance with the manufacturer's recommendations.

Cold-Applied Preformed Plastic Gaskets. Plastic gasket shall be produced from blends of refined hydrocarbon resins and plasticizing compounds reinforced with inert mineral filler and shall contain no solvents, irritating fumes, or obnoxious odors.

Expanded Cellular Rubber Gaskets. Expanded Cellular Rubber Gaskets shall be produced from tubular cross sections of a blend of nitrile and vinyl polymers meeting the physical requirement of ASTM D1056, Flexible Cellular Materials – Sponge or Expanded Rubber, Class 2C1.

Elastomeric Seals for Joining Concrete Structures. Elastomeric seals shall be produced from natural or synthetic rubber meeting the requirements of ASTM C1619 Standard Specification for Elastomeric Seals for Joining Concrete Structures.

501.6.1.4. Workmanship and Finish. Pipe shall be substantially free from fractures, large or deep cracks and surface roughness. The ends of the pipe shall be normal to the walls and centerline of the pipe within the limits of variations allowed as stated previously.

501.6.1.5. Pipe Marking. Markings shall be indented on the pipe section or painted thereon with waterproof paint. The following information shall be clearly marked on each section of pipe:

(1) the class of pipe,
(2) the date of manufacture,
(3) the name or trademark of the manufacturer,
(4) where elliptical reinforcement is used, one end of each section or joint of pipe shall be clearly marked during the process of manufacture or immediately thereafter on the inside and the outside of opposite walls to show the location of the “top” or “bottom” of the pipe as it should be installed.

501.6.1.6. Tests. The acceptability of the pipe in all diameters, strengths and classes shall be determined by such material tests performed as required in ASTM C76 (C76M), C506 or C507; by the results of the three-edge bearing test for the load to produce a 0.01-in. crack and ultimate load and by absorption tests on selected samples from the wall of the pipe in accordance with ASTM C497 (C497M) Concrete Pipe, Manhole Sections, or Tile; and by inspection of the finished pipe to determine its conformance with the design prescribed in these specifications and its freedom from defects.

Testing rates shall be as follows, except that in no case fewer than two specimens shall be furnished:

(1) If subjected to three-edge-bearing tests for the 0.01-in. crack only, testing shall be performed on 0.8-percent of the number of pipe sections of each size included in the order. Pipes that have been tested only to the formation of a 0.01-in. crack and that meet the 0.01-in. test load requirements shall be accepted for use.
(2) If subjected to three-edge-bearing tests for both the 0.01-in. crack and the ultimate load, testing shall be performed on 0.2-percent of the number of pipe sections of each size included in the order.

As an alternate to the three-edge-bearing test, concrete pipe 60-in. in diameter and over may be accepted, at the option of the manufacturer, on the basis of material tests and inspection of the completed product. Acceptability of pipe on this basis shall be determined by the results of material tests as required in ASTM C76, C506 or C507; by crushing tests on cores taken from the barrel of the completed and cured pipe; by absorption tests on samples from the wall of the pipe; and by inspection of the finished pipe, including amount and placement of reinforcement, to determine its conformance with the design prescribed in these specifications and its freedom from defects.

The manufacturer shall furnish facilities and personnel for taking the cores from the pipe barrel and for determining the compressive strength of the samples. When the cores cut from a section of pipe successfully meet the strength requirement, the core-holes shall be plugged and sealed by the manufacturer in a manner such that the pipe section shall meet all of the test requirements of ASTM C76, C506 or C507. Pipe sections, so sealed, shall be accepted for use.

Tested pipe accepted for use shall be marked “TEST” or otherwise appropriately identified. Should any of the test specimens fail to meet the test requirements, two consecutive joints in the same mix series shall be tested and results shall be a basis of accepting or rejecting the pipe of the series.

501.6.1.7. Rejection of Pipe. All rejected pipe shall be plainly marked by the OWNER and shall be replaced by the CONTRACTOR with pipe that meets the requirements of these specifications. Such rejected pipe shall be removed immediately from the site of the work.

501.6.2. Precast Reinforcement Concrete Box.

501.6.2.1. General. Precast reinforced concrete box sections shall conform to ASTM C1433 (C1433M) Standard Specifications for Precast Reinforced Concrete Monolithic Box Sections for Culverts, Storm Drains and Sewers and ASTM C1577 Standard Specification for Precast Reinforced Concrete Monolithic Box Sections for Culverts, Storm Drains, and Sewers Designed According to AASHTO

LRFD. More information may be found in ASTM C877 Standard Specification for External Sealing Bands for Concrete Pipe, Manholes, and Precast Box Sections.

501.6.2.2. Concrete. Boxes shall be machine-made or cast by process which will provide for uniform placement of concrete in forms and compaction by mechanical devices to produce dense, structurally sound concrete. Use concrete mixed in central batch plant or other batching facility from which quality and uniformity of concrete can be assured. Transit-mixed concrete is not acceptable. Representatives of the Engineer will inspect manufacturer's plant and casting operations as deemed necessary.

501.6.2.3. Joints. Joints shall conform to ASTM C990 Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants, Expanded Cellular Rubber Gaskets meeting the physical requirement of ASTM D1056, Flexible Cellular Materials - Sponge or Expanded Rubber, Class 2C1, ASTM C1677 Standard Specification for Joints for Concrete Box, Using Rubber Gaskets. For joints conforming to C1677, the elastomeric (gasket) material shall conform to ASTM C1619 Standard Specification for Elastomeric Seals for Joining Concrete Structures, Class C requirements. Gaskets which require oil resistant properties (e.g. Nitrile) shall meet Class D requirements. Gasket material for sealing tongue & groove joints shall be performed flexible butyl rubber meeting the requirements of ASTM C990 Section 6.2 Butyl Rubber Sealant, or Expanded Cellular Rubber Gaskets. Gasket width shall be in accordance with the joint material manufacturer's recommendations, and large enough to properly seal the entire perimeter of the tongue and groove joint.

501.6.2.4. Lifting Holes. For precast boxes, no more than 4 lifting holes shall be in each section. Lifting holes may be cast, cut into fresh concrete after form removal, or drilled. Lifting holes of sufficient size shall be used for adequate lifting based on the size and weight of the box section. Lifting holes larger than 3 inches in diameter are not acceptable. More than 1 longitudinal wire or 2 circumferential wires per layer of reinforcing steel may not be cut when locating lifting holes. Spalled areas around lifting holes shall be repaired when discovered.

501.6.2.5. Quality. Fine cracks on the surface of the member that do not extend to the plane of the nearest reinforcement are acceptable unless the crack are numerous and extensive.

501.6.2.6. Repairs. Cracks that extend into the plane of the reinforcement steel shall be repaired in an approved manor. Excessive damage, honeycombing, or cracking will be subject to structural review. The OWNER MAY accept box repairs that are sound, properly finished and cured in conformance with pertinent specifications.

501.7. DUCTILE-IRON PRESSURE PIPE AND FITTINGS

501.7.1. General. Ductile-iron pressure pipe 4-in. through 64-in. shall conform to the American National Standard for Ductile-Iron Pipe Centrifugally Cast for Water or Other Liquids, AWWA C151. In accordance with C151, Section III.A, purchaser options and alternatives shall be provided by the specifier, including pipe size, joint type, special joints, thickness or class, and laying length. Purchaser options and alternatives shall be specified in the supplemental conditions, plans, or technical specifications. Polyethylene encasement for ductile iron pipe systems shall conform to Item 502.8. Polyethylene Wrap for Metal Pipe and Fittings. The CONTRACTOR shall protect the polyethylene wrap and prevent damage during embedment and backfill installation.

The ductile iron shall conform in all respects to the specifications set forth in ASTM Standard A377, Standard Index of Specifications for Ductile Iron Pressure Pipe. The specific grade of ductile iron used shall be Grade 60-42-10, with a Minimum Tensile Strength of 60,000 psi, a Minimum Yield Strength of 42,000 psi, and a Minimum Elongation in 2" of 10%.

501.7.2. Joints. All ductile-iron pressure pipe shall be furnished with one of the types of joints indicated in Table 501.7.2.(a) Ductile Iron Pressure Pipe Joint Types and as described in the proposal or bid request.

Bolts and nuts for mechanical joints or flanged ends (if used underground) shall be of a high-strength low-alloy corrosion-resistant steel and shall conform to ASTM F3125 (F3125M) High Strength Structural Bolts.

All threaded flanges shall be ductile iron.

Table 501.7.2.(a) Ductile Iron Pressure Pipe Joint Types

Type Joint	AWWA Standard
Push-on	AWWA C111 Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
Mechanical Joint	AWWA C111 (same as above)
Flanged Ends	AWWA C110 Ductile-Iron and Gray-Iron Fittings, 3 in.-48 in., for Water, or AWWA C115 Flanged Ductile-Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges
Grooved Ends	AWWA C606 Grooved and Shouldered Joints

501.7.3. Coating and Lining. All ductile-iron pipe shall be bituminous coated outside and cement mortar lined inside. The cement mortar lining shall be seal coated in accordance with the latest revision of ANSI / AWWA C104 / A21.4 American National Standard for Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water. All ductile iron pipe shall require an exterior polywrap corrosion protection system as defined in the latest version of ANSI / AWWA C105 / A21.5 American National Standard for Polyethylene Encasement for Ductile-Iron Pipe Systems. In the event of tears, pinches, breaches, or other damage to the initial external polywrap protection layer, the use of dual layer external polywrap protection meeting the above standards shall be required. If this specification conflicts with manufacturer's installation recommendations, follow manufacturer's recommendations for ductile iron pipe installation.

501.7.4. Fittings. Fittings shall be of ductile-iron and shall conform to AWWA C110 ANSI Standard for Ductile-Iron and Gray-Iron Fittings, 3-in. through 48-in. for Water, or conform to AWWA C153 ANSI Standard for Ductile-Iron Compact Fittings for Water Service, 3-in. through 64-in., unless otherwise specified in the proposal, special specification or in the plans.

Welded-on outlets may be used in lieu of the tees shown on the plans. Outlet pipe shall be special thickness class 53. All weldments must be 55% nickel iron and each outlet pipe shall be air tested to 15-psi to insure weld integrity. The outlet branches must be made from ductile iron pipe.

All fittings shall be rated for a minimum of 250-psi working pressure unless otherwise specified.

Special fittings using end condition combinations of bells, spigots, mechanical, integrally restrained or push-on joints, flanges, or special internally locked joints shall be dimensioned in accordance with AWWA C110 or C153.

Bolts and nuts for mechanical joints or flanged ends shall be of a high-strength, corrosion-resistant low-alloy steel and shall conform to ASTM A325 (Type 3) or shall be stainless steel in accordance with ASTM A304 Carbon and Alloy Steel Bars Subject to End-Quench Hardenability Requirements.

The OWNER shall determine whether fittings shall be bituminous coated outside and cement-mortar lined inside with seal coat in accordance with AWWA C104 Standard for Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water or whether the interior and exterior surfaces shall be protected consistent with AWWA C116 Standard for Protective Fusion-Bonded Epoxy Coatings for the Interior and Exterior Surfaces of Ductile-Iron and Gray-Iron Fittings for Water Supply Service.

501.7.5. Tests. All ductile-iron pipe and fittings shall be tested in accordance with the applicable provisions of the specifications relating thereto.

501.7.6. Markings. Class, weight, and casting period shall be shown on each pipe.

501.8. SECTION HELD FOR FUTURE USE

501.9. STEEL PIPE AND FITTINGS

501.9.1. General. Steel pipe, fittings and specials shall conform to the details as shown on the plans or included in the specifications and as specified below. Steel Pipe and Fittings shall be provided in accordance with AWWA C200. In accordance with C200, Section III.A, purchaser options and alternatives shall be provided by the specifier, including pipe size, joint type, special joints, thickness or class, and laying length. Purchaser options and alternatives shall be specified in the supplemental conditions, plans, or technical specifications.

501.9.2. Applicable Standard Specifications. Except as modified or supplemented herein, all steel pipe, fittings and specials shall conform to the applicable requirements of the standard specifications indicated in Table 501.9.2.(a) Standards for Steel Pipe and Fittings.

Table 501.9.2.(a) Standards for Steel Pipe and Fittings

Standard	Designation
AWWA C200	Steel Water Pipe—6 in. and Larger
AWWA C203	Coal Tar Protective Coatings and Linings for Steel Water Pipeline — Enamel and Tape — Hot Applied
AWWA C205	Cement-Mortar Protective Lining and Coating for Steel Water Pipe — 4 in. and Larger — Shop Applied
AWWA C206	Field Welding of Steel Water Pipe
AWWA C207	Steel Pipe Flanges for Waterworks Service—Sizes 4 In. Through 144 in.
AWWA C208	Dimensions for Fabricated Steel Water Pipe Fittings
AWWA C209	Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections, and Fittings for Steel Water Pipe
AWWA C210	Liquid-Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines
AWWA C214	Tape Coating Systems for the Exterior of Steel Water Pipelines
AWWA C222	Polyurethane Coatings for the Interior and Exterior of Steel Water Pipelines and Fittings
AWWA C602	Cement-Mortar Lining of Water Pipelines in Place—4 in. and Larger
AWWA C606	Grooved and Shouldered Joints
ASTM A283	Low and Intermediate Tensile Strength Carbon Steel Plates
ASTM A139	Electric-Fusion (Arc)-Welded Steel Pipe (NPS 4 and Over)
NSF/ANSI 61	Drinking Water System Components

CONTRACTOR shall submit a written certification that the pipe has been manufactured and tested in accordance with the applicable standards. The pipe shall be manufactured, fabricated, coated and lined by a single manufacturer being a certified member in good standing of the Steel Plate Fabricators Association (SPFA).

501.9.3. Pipe and Fittings Requirements. Fabricated pipe and fittings shall be made of steel plate conforming to ASTM A283, Grade D, or ASTM A139, Grade B, C, or D in accordance with AWWA C200. Mill-type pipe and fittings shall be Grade B conforming to AWWA C200.

Nominal pipe diameter shall be as specified in the plans. Nominal diameters for steel pipe sizes under 24-in. are outside diameters and for sizes 24-in. and over are inside diameters per AWWA M11 Steel Pipe—A Guide for Design and Installation.

The pipe wall thickness shall be as specified in the plans.

Pipe sections shall be furnished in not less than 20 ft. lengths except for specials and closures sections as may be required.

501.9.4. Joints. Steel pipe and fittings shall be joined with any of the end types as specified below, unless a particular end type is specified. Flange ends shall be used only where specifically noted on drawings.

Welded joints shall conform to and be tested in accordance with AWWA C206.

Rubber gasketed joints may be used up to 72-in. in diameter and shall conform to, and be tested in accordance with AWWA C200.

Grooved and shouldered joints shall conform to, and be tested in accordance with AWWA C606.

Mechanically coupled joints shall consist of Dresser Couplings Style 38 or equal or as specified on the drawings.

Flanged joints shall conform to the AWWA C207, Class D. The thickness of flanges shall be as specified in Table 1 or 2 of AWWA C207, or as specified on the drawings.

501.9.5. Lining and Coating. Steel pipe and fittings shall be lined in accordance with any of the standards indicated in Table 501.9.5.(a) Lining and Coating for Steel Pipe and Fittings, unless a particular specification is shown on the plans.

The exterior surface of steel pipe and fittings to be installed underground shall be coated in accordance with AWWA C214. If coated in accordance with AWWA C214, then the fittings will be coated in accordance with AWWA C209. The exterior surface of steel pipe and fittings to be installed above ground shall be cleaned, primed and coated, all in accordance with either AWWA C222 or C210.

Table 501.9.5.(a) Lining and Coating for Steel Pipe and Fittings

Standard	Topic
AWWA C205	Cement-Mortar Protective Lining and Coating for Steel Water Pipe — 4 In. and Larger — Shop Applied
AWWA C210	Liquid-Epoxy Coating Systems for Interior and Exterior of Steel Water Pipelines
AWWA C222	Polyurethane Coatings for the Interior and Exterior of Steel Water Pipelines and Fittings
AWWA C602	Cement-Mortar Lining of Water Pipeline — 4 In. and Larger — in Place

501.9.6. Testing. All steel pipe shall be hydrostatically tested to a pressure that will induce a stress of 75% of the minimum yield strength of the steel in accordance with AWWA C200. Fittings fabricated from hydrostatically tested pipe shall not require shop hydrostatic testing. Welds for fittings that were not previously hydrostatically tested shall require hydrostatic testing, air testing, or other ASTM nondestructive testing.

501.10. SEAMLESS COPPER TUBING

501.10.1. General. These specifications pertain only to Type K, annealed (soft) copper water tubing for use with solder, flared, or compression-type fittings. The copper tubing shall conform to ASTM B88 Seamless Copper Water Tube.

501.10.2. Quality. The vendor shall be responsible for submission of a laboratory analysis of the products supplied. The manufacturer's own laboratory analysis is acceptable. The certificate of analysis shall state size and type of analysis and results obtained. A statement shall be made and validated that tests confirm compliance with the requirements of this specification.

The OWNER reserves the right to conduct or cause to have conducted independent laboratory tests. Where the results of such tests prove the quality requirements have not been met: (1) the costs of tests shall be charged to the vendor's account, and (2) the entire shipment may be rejected on the basis of such tests.

501.11. CORRUGATED METAL PIPE OR PIPE ARCH SHAPES

501.11.1. General. This item shall govern the furnishing of corrugated metal pipe for culverts and storm water conduit for the locations and designations as shown on the plans and contract specifications as herein outlined.

Pipe having a design hydraulic head exceeding 5-ft. of water will have helical corrugations and the lock seam shall be either continuously welded or caulked with a neoprene or mastic seal during fabrication. Caulked helical pipe shall be fabricated by applying a uniform bead of neoprene or mastic compound to the lock seam in such a manner that the inner surfaces of the lock seam are free of voids.

Shell Data shall specify diameter, classification (Type), material, gage and corrugation. This information shall be designated on the plans and/or contract specifications.

501.11.2. Pipe Manufacture. Corrugated metal pipe or pipe arch shapes shall meet the requirements of ASTM A760 (A760M) Corrugated Steel Pipe, Metallic-Coated for Sewers and Drains, ASTM B745 (B745M) Corrugated Aluminum Pipe for Sewers and Drains, or ASTM A742 (A742M) Steel Sheet, Metallic Coated and Polymer Precoated for Corrugated Steel Pipe. All pipe shall be manufactured with a minimum of two re-rolled ends

501.11.2.1. Steel Pipe. Galvanized or aluminized steel pipe shall be full circle or arch pipe conforming to AASHTO Designation M36, Type I, Type II or Type III as specified in the plans.

501.11.2.2. Aluminum Pipe. Aluminum pipe shall conform to the requirements of AASHTO Designation M196, Type I, Type II or Type III pipe arch as specified on the plans.

Aluminum pipe may be placed bare of any precoating, but any portions of aluminum pipe that are to be in contact with a metal other than aluminum or in contact with concrete containing chlorides, shall be insulated from this other metal or concrete by a coating of bituminous material or a plastic coating, such as asphalt mastic or polymeric coating. The coating applied to the aluminum pipe or pipe arch to provide an insulation between the aluminum and other metal shall extend a minimum distance of 1 ft. beyond the area of contact.

501.11.2.3. Precoated Galvanized or Aluminized Steel Pipe. Pipe shall be full circle or arch pipe conforming to AASHTO Designation M245, Type I, Type II or Type III as specified in the plans.

501.11.3. Classification (Type). Corrugated metal pipe shall be classified on the plans and/or specifications with the notations as set forth in ASTM A760 (A760M), ASTM B745 (B745M) and ASTM A742 (A742M) and indicated in Table 501.11.3.(a) Corrugated Metal Pipe Type.

Table 501.11.3.(a) Corrugated Metal Pipe Type

Type	Description
Type I	Pipe with a full circular cross section with a singular thickness of corrugated sheet, fabricated with annular or helical corrugations.
Type IA	Pipe with a full circular cross section, with an outer shell of corrugated sheet fabricated with helical corrugations and an inner liner of smooth (uncorrugated) sheet attached to the shell at helical lock seams. Unless otherwise shown on the plans or contract specifications, the inner liner of smooth (uncorrugated) sheets shall be 18-gage, polymer coated per ASTM A762 (A762M) Grade 10/10 or 20-gage, polymer coated per ASTM A762 (A762M) Grade 10/10.
Type IR	Pipe with a full circular cross section, with a single thickness of smooth sheet, fabricated with helical ribs projecting outward.
Type II	Type I pipe which has been reformed into a pipe-arch, having an approximately flat bottom.
Type IIA	Type IA pipe which has been reformed into a pipe-arch, having an approximately flat bottom.
Type IIR	Type IR pipe which has been reformed into a pipe-arch, having an approximately flat bottom.
Type III	Type I pipe which has been perforated to permit the inflow and outflow of water, intended for use as underdrains.
Type IIIA	Pipe shall consist of semi-circular cross section having a smooth bottom with a corrugated top shield which has been perforated, intended for use as deck drains.

501.11.4. Material. Corrugated metal pipe or pipe arch shapes shall be fabricated from corrugated sheets conforming to one of the styles indicated in Table 501.11.4.(a) Corrugated Sheets for Pipe or Pipe Arch Shapes.

Table 501.11.4.(a) Corrugated Sheets for Pipe or Pipe Arch Shapes

Metal		Standards
GALV	Galvanized Steel	ASTM A760 (A760M) Corrugated Steel Pipe, Metallic-Coated for Sewers and Drains
ALT2	Aluminized Type 2 Steel	ASTM A760 (A760M) (same as above)
POLY	Polymeric Steel	ASTM A762 (A762M) Corrugated Steel Pipe, Polymer Precoated for Sewers and Drains (Grade 10/10)
ALUM	Aluminum Alloy	ASTM B744 (B744M) Aluminum Alloy Sheet for Corrugated Aluminum Pipe

501.11.5. Gage. Where reference is made to gage of metal, the reference is to U.S. Standard Gage for uncoated sheets in ASTM A929 (A929M) Steel Sheet, Metallic-Coated by the Hot-Dip Process for

Corrugated Steel Pipe. Unless otherwise shown on the plans or contract specifications, minimum gages shall be as required by TxDOT *Standard Specifications for Construction of Highways, Streets and Bridges*, Item 460.4. Selection of Gages.

501.11.6. Corrugation. Corrugated configurations shall be governed by dimensional tolerances set forth in ASTM A760 (A760M). The corrugations as shown in Table 501.11.6.(a) Corrugation Configurations shall only be valid with their respective classifications (type).

Table 501.11.6.(a) Corrugation Configurations

Type	Configuration
Type 1	2⅔-in. x ½-in.; 3-in. x 1-in.; 5-in. x 1-in.
Type IA	2⅔-in. x ½-in.; 3-in. x 1- in.
Type IR	¾-in. x ¾-in. x 7½-in.; ¾-in. x 1-in. x 11½-in.
Type II	2⅔-in. x ½-in.; 3-in. x 1-in.; 5-in. x 1-in.
Type IIA	2⅔-in. x ½-in.; 3-in. x 1-in.
Type IIR	¾-in. x ¾-in. x 7½-in.; ¾-in. x 1-in. x 11½-in.
Type III	2⅔-in. x ½-in.; 3-in. x 1-in.

501.11.7. Repairs. All damage incurred in fabrication will be repaired at the fabrication location. Damage incurred during handling and placement will be repaired, inspected and approved by the OWNER prior to backfilling the pipe.

501.11.7.1. Galvanized Steel Pipe. Damaged spelter coating shall be repaired by thoroughly wire brushing the damaged area and removing all loose, cracked or weld burned spelter coating. The cleaned area shall be painted with a zinc dust-zinc oxide paint conforming to Federal Specifications TT-P-641.

501.11.7.2. Aluminized Steel Pipe. Damaged areas of aluminized coating, including saw cut ends and welds, shall be cleaned and repaired by brush coating of aluminized paint to the damaged, cut or welded area to a minimum thickness of 0.005-in.

501.11.7.3. Precoated Pipe. Damaged or cut areas of polymeric coatings shall be repainted by the application of a polymeric coating similar and compatible with the polymeric coating on the pipe and to a minimum 10-mil thickness.

Damaged areas of bituminous coated galvanized steel shall be repaired by repair of any damaged areas of spelter coatings in accordance with Item 501.11.7.1. Galvanized Steel Pipe before repairing the bituminous coating by applying asphalt mastic to the same thickness as the original coating.

501.11.8. Pipe Marking. The following information shall be clearly marked on each section of pipe:

(1) Date of manufacture of the pipe.
(2) The name or trademark of the manufacturer of the pipe.
(3) Gage or thickness of metal.
(4) Alloy number (aluminum pipe only).

501.11.9. Couplings.

501.11.9.1. Coupling Bands. Except as may be otherwise required, coupling bands shall be of the same base material(s) as the pipe. Coupling bands shall lap evenly on each of the pipes being connected and shall fit securely into a least one full circumferential corrugation to form a tightly closed joint. Pipe end circumferential corrugations shall be the corrugation width and depth as shown on the plans or as specified by the Engineer.

All pipe shall be field jointed with corrugated locking bands. Coupling bands shall not be more than three nominal sheet thicknesses lighter than the pipe to be connected and in no case thinner than 0.052-in. The minimum width of the corrugated locking bands shall be as shown in Table 501.11.9.1.(a) Corrugated Locking Band Width for the corrugation which corresponds to the end circumferential corrugations on the pipe being joined.

Table 501.11.9.1.(a) Corrugated Locking Band Width

Corrugation	Minimum Band Width
2⅔-in. x ½-in.	10½-in.
3-in. x 1-in.	12-in.
6-in. x 1-in.	18-in.

When it is necessary to join a new pipe of helical corrugations to an existing pipe which was installed with no circumferential end corrugations, the two pipes shall be field jointed with helically corrugated bands. The width of helically corrugated bands shall conform to the minimum widths in Table 501.11.9.1.(b) Helically Corrugated Band Width.

Table 501.11.9.1.(b) Helically Corrugated Band Width

Helical End Corrugation	Minimum Band Width
½-in. deep	12-in.
1-in. deep	14-in.

All coupling bands 12-in. wide or less shall be drawn together by means of a minimum of two ½-in. diameter bolts through angles or bar and strap device suitably welded; coupling bands greater than 12-in. wide shall have a minimum of three ½-in. diameter bolts.

501.11.9.2. Bell-and-Spigot Coupling. Except as may otherwise be required, bell-and-spigot couplings shall be of the same base material as the pipe, and in no case thinner than 0.052-in.

Couplings shall be bell and spigot type. The bell shall have a corrugation to engage the rerolled annular corrugation in the pipe, with a flare to receive the spigot end of the next section of pipe. The bell shall have factory-welded lap(s) applied after snugging the bell corrugation into the pipe rerolled annular corrugation.

Gaskets, if required, shall be polyisoprene (or similar) with a durometer of 45 ±5. The gasket on the spigot end shall be fluted with two flutes to prevent rolling when assembled in the field and to resist pull out from the bell.

501.12. STRUCTURAL PLATE STRUCTURES

501.12.1. General. Structural plate conduit, pipe arch, box culverts and special shapes shall meet the requirements of TxDOT *Standard Specifications for Construction of Highways, Streets and Bridges* Item 461 Structural Plate Structures and be in accordance with ASTM A761 Corrugated Steel Structural Plate, Zinc-Coated, for Field-Bolted Pipe, Pipe-Arches, and Arches for galvanized steel structures or ASTM B221 Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes, for aluminum alloy structures.

501.12.2. Plates. Steel plates shall consist of structural units of corrugated galvanized metal. Single plates shall be furnished in standard sizes to permit structure length increments of 2-ft. Aluminum plate shall consist of structural units of corrugated aluminum alloy. For aluminum alloy structures, cut plates shall be furnished on structure ends to permit structure length increments of 1-ft.

Plates shall be formed to provide bolted lap joints. The bolt holes shall be so punched that all plates having like dimensions, curvature, and the same number of bolts per foot of seam shall be interchangeable. Each plate shall be curved to the proper radius so that the cross-sectional dimensions of the finished structure will be as indicated on the plans. Joints shall be staggered so that not more than 3 plates are joined at any one point. Unless otherwise specified, bolt holes along those edges of the plates that will form longitudinal seams in the finished structure shall be:

(1) staggered in rows 2-inches apart, with one row in the valley and one in the crest of the corrugations and not less than 4-bolts-per-foot for galvanized steel structures, or
(2) in rows 1¾-in. apart with 2 bolts in each valley and on each crest and not less than 16-bolts-per-3-feet for aluminum alloy structures.

Bolt holes along those edges of the plates that will form circumferential seams in the finished structure shall provide for a bolt spacing of not more than 12-in. The minimum distance from center of hole to edge of the plate shall be not less than 1¾-times the diameter of the bolt. The diameter of the bolt holes in the longitudinal seams shall not exceed the diameter of the bolt by more than ¼-in. Plates for forming skewed or sloped ends shall be cut so as to give the angle of skew or slope specified. Burned edges shall be free from oxide and burrs and shall present a workmanlike finish and legible identification numerals shall be placed on each plate to designate its proper position in the finished structure.

501.12.3. Corrugations. Permissible corrugations of metal plates to be furnished for each structure shall be shown on the plans. Corrugations for steel structures shall have a pitch of 6-in. with a tolerance of ¼-in. and a depth of 2-in. with a tolerance of ⅛-in. The radius on the inside of the corrugations shall be at least $1^{1}/_{16}$-in. for steel structures. Corrugations for aluminum alloy structures shall have a pitch of 9-in. with a tolerance of ⅜-in. and a depth of 2½-in. with a tolerance of ⅛-in. The radius of the inside of the corrugation shall be at least 2-in. for aluminum alloy structures.

501.12.4. Gauge Determination and Tolerances. The gage or minimum thickness of metal plates to be furnished for each structure shall be shown on the plans. The gauge and tolerances of aluminum plates shall conform to those in ASTM B221 Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes. The thickness of galvanized steel plates shall conform to those in ASTM A929/A929M Steel Sheet, Metallic-Coated by the Hot-Dip Process for Corrugated Steel Pipe.

501.12.5. Metal Headwalls. The material for metal headwalls shall comply with requirements shown on plans. When required, aluminum alloy inverts, toewalls footings and closure plates shall conform to the material requirements herein. Extruded aluminum transverse stiffeners shall conform to ASTM B221 Aluminum and Aluminum-Alloy Extruded Bars, Rods, Wire, Profiles, and Tubes, Alloy 6061-T6.

501.12.6. Fasteners. Fasteners for steel structural plate shapes shall be high strength bolts ¾-in. diameter, hot-dip galvanized, meeting ASTM A449 Quenched and Tempered Steel Bolts and Studs. Nuts shall conform to ASTM A563 Carbon and Alloy Steel Nuts, Grade C. Fasteners for aluminum structural plate shapes shall be ¾-in. diameter, hot-dip galvanized steel, meeting ASTM A307 Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength with the zinc coating in accordance with ASTM A153 Zinc Coating (Hot-Dip) on Iron and Steel Hardware. Nuts shall conform to ASTM A563, Grade A.

Bolt lengths shall be such as to result in at least “full nuts” when tightened in place.

501.12.7. Anchor Bolts. Anchor bolts for anchoring the ends of structural plate conduits into concrete headwall, footings or toewalls, as shown on the plans, shall be ¾-in. diameter conforming to ASTM A307 Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength with the zinc coating in accordance with ASTM A153 Zinc Coating (Hot-Dip) on Iron and Steel Hardware. The length, shape and placement of these anchor bolts shall be as shown on the plans or approved by the Engineer.

501.12.8. Identification. No plates shall be accepted unless the metal is identified by a stamp on each plate in accordance with AASHTO M167 for Steel Structural Plate or AASHTO M219 for Aluminum Alloy Structural Plates.

501.12.9. Inspections. If the Engineer so elects, it may have the material inspected and sampled in the rolling mill or in the shop where fabricated. Engineer may require from the mill the chemical analysis of any plate. The inspection, either in the mill or in the shop, shall be under the directions of the Engineer. The Engineer or its representative shall have free access to the mill or shop for inspection and every facility shall be extended to the Engineer or representative for this purpose. Any material that has been previously rejected at the mill or shop and included in a later lot will be cause for rejection unless it has been satisfactorily repaired.

The CONTRACTOR shall furnish an itemized statement of the number and size of plates in each shipment. From this list a visual inspection shall include an examination of the plates for deficiency in size, radius of curvature specified, and any evidence of poor workmanship as outlined herein. The inspection may include the taking of samples for chemical analysis and determination of weight of spelter coating on steel plates. The plates making up the shipment shall fully meet the requirements of these specifications. Any plates failing to do so will be rejected.

501.12.10. Rejection. In addition to the provisions of Item 501.1.1. Rejection, structures shall be rejected on which the spelter coating has been bruised or broken either in the shop or in shipping, or which shows defective workmanship. The requirement applies not only to the individual plates but also to the shipment on any contract as a whole. Among others, the following defects are specified as constituting poor workmanship, and the presence of any or all of them in any individual culvert plate or in general in any shipment shall constitute sufficient cause for rejection:

(1) elliptical shaping,
(2) variation from a straight centerline,
(3) ragged edges,
(4) unevenly lined or spaced bolt holes,
(5) illegible brands,
(6) bruised, scaled or broken spelter coating,
(7) dents or bends in the metal itself, or
(8) uneven laps.

501.13. TUNNEL LINER PLATES

501.13.1. General. This specification covers the material, galvanizing, coating, shapes and gauge requirements of tunnel liner plates for use in tunneling under railroads, highways and streets.

501.13.2. Plates. The plates shall be fabricated from steel sheets conforming to the requirements of ASTM A1011 Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy and High-Strength Low-Alloy with Improved Formability. In addition, the flat plates before cold forming shall have mechanical properties indicated in Table 501.13.2.1.(a) Tunnel Liner Plate Requirements.

501.13.2.1.(a) Tunnel Liner Plate Requirements

Property	Minimum Value
Tensile Strength	42,000-psi
Yield Strength	28,000-psi
Elongation, 2-in.	30-percent

501.13.3. Bolts and Nuts. Bolts used with lapped seam type (2 flange) liner plates shall be not less than $^{5}/_{8}$-in. diameter. Bolts shall conform to ASTM A449 Quenched and Tempered Steel Bolts and Studs for plate thickness equal to or greater than 0.209-in. and to ASTM A307 Carbon Steel Bolts and Studs, 60,000 PSI Tensile Strength for plate thickness less than 0.209-in. Nuts shall conform to ASTM A307.

Bolts and nuts used with the four-flanged type shall be not less than $^{1}/_{2}$-in. for 7-gauge plates and lighter and not less than $^{5}/_{8}$-in. diameter for plats heavier than 7-gauge. The bolts and nuts shall be quick acting coarse thread and shall conform to ASTM A307, Grade A.

501.13.4. Fabrication. The plates shall be new and unused prior to fabrication. All plates shall be punched for bolting on both longitudinal and circumferential seams or joints and shall be so fabricated as to permit complete erection from the inside of the tunnel. All plates shall be of uniform fabrication and those intended for one size tunnel shall be interchangeable.

501.13.5. Grout Holes. One-half of the total number of the top plates shall be equipped with 2-in. diameter grout holes to facilitate grouting above and around the tunnel liner conduit. All grout holes shall be equipped with screw type galvanized plugs for final watertight closure of the grout holes.

501.13.6. Galvanizing. After the plates are formed to shape and after all holes are punched, the plates shall be galvanized on all surfaces by the hot-dip process. A coating of prime western spelter or equal shall be applied in accordance with ASTM A123 Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products. Spelter coating shall be of first-class commercial quality free from injurious defects such as blisters, flux and uncoated spots. All nuts shall be galvanized to conform to ASTM A153 Zinc Coating (Hot-Dip) on Iron and Steel Hardware.

501.13.7. Bituminous Coating. The plates shall be given a bituminous coating meeting the current American Railway Engineering & Maintenance of Way Association specification or ASTM A849 Post-Applied

Coatings, Pavings, and Linings for Corrugated Steel Sewer and Drainage Pipe. Bituminous protected corrugated metal pipe or plates may be spray-coated in the field with a minimum dry film thickness of 0.05-in. prior to installation.

501.13.8. Section Properties. Section properties shall conform to those specified in AASHTO Standard Design Specifications for Highway Bridges, Section 16, Steel Tunnel Liner Plates.

501.13.9. Rejection. Structures on which the spelter coating has been bruised or broken either in the shop or in shipping or which shows defective workmanship shall be rejected. The requirement applies not only to the individual plates but also to the shipment on any contract as a whole. Among others, the following defects are specified as constituting poor workmanship, and the presence of any or all of them in any individual liner plate or in general in any shipment shall constitute sufficient cause for rejection:

(1) uneven laps,
(2) elliptical shaping,
(3) variation from a straight centerline,
(4) ragged edges,
(5) unevenly lined or spaced bolt holes,
(6) illegible brands,
(7) bruised, scaled or broken spelter coating, or
(8) dents or bends in the metal itself.

501.14. POLYVINYL CHLORIDE (PVC) WATER PIPE

501.14.1. General. Unplasticized polyvinyl chloride (PVC) water pipe shall meet the requirements of AWWA C900, sizes 4-in. to 60-in. diameter. In accordance with C900, Section III.A, purchaser options and alternatives shall be provided by the specifier, including working, occasional, and recurring surge pressures, pressure class, or dimension ratio (DR). Purchaser options and alternatives shall be specified in the supplemental conditions, plans, or technical specifications. Laying lengths shall be 20-ft ±1-in.

501.14.2. Approvals. PVC water pipe shall be approved by the Underwriters' Laboratories and shall be accepted by the State Fire Insurance Commission for use in water distribution systems in cities and towns of Texas. PVC water pipe shall also bear the seal of approval (or "NSF" mark) of the National Sanitation Foundation Testing Laboratory for potable water pipe.

501.14.3. Dimension Ratio. PVC water pipe shall meet the dimension ratios (DR's) and physical dimensions as shown in AWWA C900. The pressure classification refers to the maximum hydrostatic pressure to which the pipe shall be subjected in normal operations.

501.14.4. Joints. PVC water pipe shall be furnished with gasketed joints. Lubricant used for pipe and fittings assembly shall be nontoxic and in conformance to NSF61. The lubricant shall have no detrimental effect to either gasket or pipe.

501.14.5. Fittings. Fittings for PVC water pipe shall conform to one of the standards Table 501.14.5.(a) PVC Water Pipe Fittings unless otherwise specified. Fittings joints shall be push-on, integrally restrained, or mechanical. Bolts and nuts for mechanical and integrally restrained fittings joints shall be of a high-strength, corrosion-resistant, low-alloy steel and shall conform to ASTM A325 High Strength Bolts for Standard Steel Joints (Type 3) or shall be stainless steel in accordance with ASTM A304.

Table 501.14.5.(a) PVC Water Pipe Fittings Standards

Standard	Topic
AWWA C110 (ANSI A21.10)	Ductile-Iron and Gray-Iron Fittings, 3 in. Through 48 in. for Water
AWWA C153	ANSI Standard for Ductile-Iron Compact Fittings for Water Service
AWWA C907	Polyvinyl Chloride (PVC) Pressure Fittings for Water—4 in. Through 8 in.
AWWA C900	Polyvinyl Chloride (PVC) Pressure Pipe, and Fabricated Fittings, 4 in. Through 12 in. or Water Distribution

501.15. POLYVINYL CHLORIDE (PVC) PRESSURE-RATED PIPE (SDR SERIES)

501.15.1. General. PVC pressure-rated pipe shall conform to the current ASTM D2241, Poly (Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series).

501.15.2. Material. The pipe shall be made of PVC plastic having cell classifications of 12454 or 13343 in accordance with ASTM D1784.

501.15.3. Joints. Joint tightness shall be tested in accordance with ASTM D3139, Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals.

501.15.4. Testing. All pipe shall meet ASTM requirements for sustained pressure test, accelerated regression test, burst pressure, flattening and impact resistance.

501.16. MOLECULARLY ORIENTED POLYVINYL CHLORIDE (PVCO) WATER PIPE

501.16.1. General. Unplasticized (PVCO) Water pipe shall meet the requirements of AWWA Standard C909 Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Pipe, 4 In. – 24 In., for Water Distribution. Laying length shall be 20ft ± 1 inch.

501.16.2. Material. PVCO water pipe starting stock shall be made from ASTM D1784 cell class 12454 material, having an Hydrostatic Design Basis (HDB) of 4000-psi. When orientation is achieved, PVCO pipe will have an HDB of 7100-psi. The pressure classifications refer to the maximum hydrostatic pressure to which the pipe shall be subject in normal operations.

501.16.3. Dimensions. Dimensions shall conform to the requirements in AWWA C909.

501.16.4. Joints. PVCO water pipe shall be furnished with gasketed joints, meeting ASTM D3139 Joints for Plastic Pressure Pipes using Elastomeric Seals. Lubricant used for pipe and fittings assembly shall be nontoxic and shall have no detrimental effect to either gasket or pipe. Solvent cement shall not be used with PVCO pipe.

501.16.5. Fittings. Fittings for PVCO water pipe shall conform to American National Standard for Gray-Iron and Ductile-Iron Fittings, 3 In. through 48 In., For Water and Other Liquids, AWWA Standard C110 (ANSI A21.10) or AWWA C907 for Polyvinyl Chloride (PVC) Pressure Fittings for Water, 4 In. through 12 In., or AWWA C153 ANSI Standard for Ductile-Iron Compact Fittings for Water Service unless otherwise specified. Fittings joints shall be push-on or mechanical joints. Bolts and nuts for mechanical joints shall be of a high-strength, corrosion-resistant, low-alloy steel and shall conform to High Strength Bolts for Standard Steel Joints, ASTM A325 (Type 3) or stainless steel in accordance with ASTM A304.

501.17. POLYVINYL CHLORIDE (PVC) WASTEWATER PIPE & FITTINGS WITH DIMENSION CONTROL

501.17.1. General. PVC Wastewater Pipe and Fittings shall conform to ASTM D3034 Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings for 4 in. through 15 in. diameter and ASTM F679 Poly(Vinyl Chloride) (PVC) Large-Diameter Plastic Gravity Sewer Pipe and Fittings for greater than 15 in. diameter.

501.17.2. Material. The pipe shall be made of PVC plastic having cell classification of 12454, or 12364, and fittings shall be made of PVC plastic having cell classifications of 12454, or 13343 as defined in ASTM D1784 Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds. Pipe type shall be determined by size as shown in Table 501.17.2.(a) PVC Wastewater Pipe Type.

501.17.2.(a) PVC Wastewater Pipe Type

Pipe Size (diameter)	Type	Standard
4-in. through 15-in., inclusive	Pipe stiffness of 46, 115 and 153	ASTM D3034
greater than 15-in.	Pipe stiffness of 46, 75 and 115	ASTM F679

501.17.3. Dimensions. Dimensions shall conform to requirements of ASTM D3034 or F679.

501.17.4. Testing. All pipe shall meet ASTM requirements for flattening, impact resistance, stiffness, joint tightness and extrusion quality as specified in ASTM D3034 or F679.

501.18. POLYVINYL CHLORIDE (PVC) PROFILE GRAVITY WASTEWATER PIPE AND FITTINGS – FOR DIRECT BURY AND SLIPLINING APPLICATIONS

501.18.1. General. This specification designates requirements for PVC plastic gravity wastewater pipe for the conveyance of domestic wastewater with various modified wall profiles and performance requirements.

501.18.2. Stiffness. Minimum pipe stiffness at five percent deflection shall be 46-psi for wastewater conduit as specified for all sizes when calculated in accordance with ASTM D2412 Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading.

501.18.3. Pipe Classification. Pipe as indicated on the plans shall conform to one of the standards in Table 501.18.3. PVC Profile Gravity Pipe Standards.

501.19. PVC COMPOSITE PIPE FOR WASTEWATER CONDUITS

501.19.1. General. PVC composite pipe shall conform to ASTM D2680 Acrylonitrile-Butadiene-Styrene (ABS) and Poly (Vinyl Chloride) (PVC) Composite Sewer Piping for 8 in. through 15 in diameter. Acrylonitrile-Butadiene-Styrene (ABS) shall not be allowed.

501.19.2. Joints, Couplings and Fittings. Wyes or tees with saddle shall be provided as indicated on the plans. Adapters to other types of pipe shall be supplied as indicated on the plans.

501.19.2.1. Chemically Welded Joints. If the pipe is plane ended with couplings, the pipe shall be delivered prebelled. Sufficient primer and solvent cement shall be provided. The solvent cement shall conform to ASTM D2564 Solvent Cements for Poly (Vinyl Chloride) (PVC) Plastic Piping Systems.

501.19.2.2. O-Ring Joints. If the pipe is prebelled with an enlarged coupling, an O-Ring shall be provided for each joint. The physical properties of the gasket shall be at least equal to the requirements of ASTM C443 Joints for Circular Concrete Sewer and Culvert Pipe, Using Rubber Gaskets.

501.19.3. Tests. The pipe stiffness at five-percent vertical deflection shall be at best equal to or exceed 200-lb./in. of deflection for each diameter as determined by ASTM D2412 Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading. The physical test may be the 3-Edge Bearing Method under applicable ASTM Designation if preferred.

501.20. SECTION HELD FOR FUTURE USE.

501.21. SOLID WALL POLYETHYLENE PLASTIC PIPE FOR WATER, WASTEWATER, AND PIPE REHABILITATION

501.21.1. General. Pipe and fittings shall conform to the material and physical properties as described in ASTM F714 Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter, unless otherwise specified herein or in the special specifications. Standard Lengths shall be 40-ft or 50-ft for straight pipe. Coiled pipe may be obtained in reels of 500-ft, 1000-ft or 1500-ft depending on outside diameter and Dimension Ratio (DR) requested.

Solid wall high density polyethylene pipe (HDPE) for pressure water pipe shall meet the requirements of AWWA C901 Polyethylene (PE) Pressure Pipe and Tubing, ½ in. Through 3 In., for Water Service or AWWA C906 Polyethylene (PE) Pressure Pipe and Fittings, 4 In. Through 63 In., for Water Distribution.

501.21.2. Material. Pipe and fittings shall be made of high density, high molecular weight polyethylene pipe PE3408 material, polyethylene resin which conforms to Polyethylene Plastics Molding and Extrusion Materials, meeting the requirements of Type III, Grade P33, as defined in ASTM D3350 Polyethylene Plastics Pipe and Fittings Materials. The polyethylene plastic shall meet the Cell Classification requirements of 345464C or 345464E as defined in ASTM D3350. Pipe for non-pressure applications shall have a light colored interior for video inspection, unless otherwise specified in the plans, contract documents or purchase request.

501.21.3. Dimensions. The polyethylene (PE) pipe shall meet the dimension ratios and outside diameter, wall thickness and tolerances as provided in the reference specifications of manufacture as listed in Table 501.21.3.(a) Solid Wall PE Pipe Dimension Standards. Diameters and wall thickness other than those shown in the standards may be used if specifically called for in the plans, contract documents or purchase request, and if they are mutually agreed upon by the manufacturer and OWNER.

Table 501.21.3.(a) Solid Wall PE Pipe Dimension Standards.

Standard	Topic
AWWA C901	Polyethylene (PE) Pressure Pipe and Tubing, ½ in Through 3 in for Water Service
AWWA C906	Polyethylene (PE) Pressure Pipe and Fittings, 4in through 63in for Water Distribution and Transmission
ASTM D2239	Polyethylene (PE) Plastic Pipe (SIDR-PR) Based on Controlled Inside Diameter
ASTM D2737	Polyethylene (PE) Plastic Tubing
ASTM D3035	Polyethylene (PE) Plastic Pipe Based on Controlled Outside Diameter
ASTM F714	Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter

501.21.4. Joints. Dependent upon installation requirements, site location, weather conditions, and the presence of water, joining shall be performed within or outside the excavation.

Sections of polyethylene pipe and fittings shall be joined by the butt fusion process, unless an alternate method is approved by the OWNER. The butt (heat) fusion method shall be performed in accordance with the pipe manufacturer's recommendations. Electrofusion fittings shall be used. Extrusion welding or hot gas welding of PE shall not be used for pressure pipe application or fabrications where shear or structural strength is important.

501.21.5. Tests and Requirements. Tests for compliance with this specification shall be made as specified herein and according to the applicable ASTM or AWWA Standard(s). All polyethylene pipe shall be tested for brittleness, joint separation, quality, and ring stiffness as specified in the applicable ASTM or AWWA Standard(s). A certification of compliance with this specification shall be furnished by the manufacturer for all material furnished under this specification. In addition, the OWNER may, at its own expense, witness inspection and test of the materials.

501.21.5.1. Tensile Properties. The tensile strength, yield strength, elongation and elastic modulus of the material shall be determined in accordance with Tensile Properties for Plastics, ASTM D638 (D 638M).

501.21.5.2. Hydrostatic Properties. The long term hydrostatic strength rating shall be listed in the name of the pipe and fittings manufacturer in PPI (Plastic Pipe Institute) TR-4, Recommended Hydrostatic Strengths and Design Stresses for Thermoplastic Pipe and Fittings compounds, with a standard grade HDB rating of 1600-psi at 73°F.

501.21.5.3. Melt Index. The melt index of the polyethylene plastic, as determined in accordance with ASTM D1238 Flow Rates of Thermoplastics by Extrusion Plastometer, shall meet the requirements as specified in ASTM D3350 Cell Classification of 4.

501.21.5.4. Density. The density of the polyethylene plastic, as determined in accordance with ASTM D1505 Density of Plastics by the Density - Gradient Technique shall have specific base resin densities meeting the requirements as specified in ASTM D3350 Cell Classification 3.

501.21.5.5. Environmental Stress Cracking Resistance. The environmental stress cracking resistance (ESCR) of the material shall meet the requirements as specified in ASTM D3350 Cell Classification of 6 using ASTM F1473 (PENT) or meet a Cell Classification of 4 according to ASTM D1693.

501.21.5.6. Wastewater Pipe Stiffness. Minimum pipe stiffness at five-percent deflection shall be 46-psi for all sizes of gravity and pressure wastewater conduits as specified in Section XI “Deflection Control In Unpressurized Polyethylene Piping Systems,” Table X1.1 “Pipe Stiffness Ranges for Specified Materials” and DR's of ASTM F714.

501.22. POLYETHYLENE (PE) LARGE DIAMETER WASTEWATER PIPE WITH MODIFIED WALL PROFILES AND PERFORMANCE STANDARDS

501.22.1. General. High Density Polyethylene gravity wastewater pipe and fittings in nominal sizes 18-in. through 120-in. with integral bell joints shall conform to current ASTM F894 Polyethylene (PE) Large Diameter Profile Wall Sewer and Drain Pipe.

501.22.2. Materials. The pipe and fittings shall be made of high density, high molecular weight polyethylene pipe material meeting the requirements of Type III, Class C, Category 5, Grade P34, as defined in ASTM D3350 Polyethylene Plastics Pipe and Fittings Materials with a minimum cell classification of 345444C.

501.22.3. Stiffness. Minimum pipe stiffness at five-percent deflection shall be 10-psi for wastewater as specified for all sizes when calculated according to Appendix XI, "Relation of RSC To Pipe Properties and Pipe Stiffness" of ASTM F894.

501.22.4. Joints. Joint tightness shall be tested in accordance with ASTM D3212 Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.

501.22.5. Testing. Pipe shall be tested for flattening, quality and ring stiffness as specified in the applicable ASTM Designations.

501.23. THERMOPLASTIC CORRUGATED DRAINAGE TUBING AND CORRUGATED SMOOTH LINED STORM WATER PIPE AND FITTINGS

501.23.1. General. High Density Corrugated and Corrugated Smooth Lined Thermoplastic storm water tube/pipe and fittings shall conform to Table 501.23.1.(a) Thermoplastic Storm Water Pipe and Fittings.

Table 501.23.1.(a) Thermoplastic Storm Water Pipe and Fittings.

Pipe Material	Topic	Standard
Polyvinyl Chloride (PVC)	PVC Corrugated Storm Water Pipe With A Smooth Interior	ASTM F949 (4"-36")
Polyethylene (PE)	PE Corrugated Pipe With A Smooth Interior	AASHTO M294 (12"-60") AASHTO M252 (3"-10")
Polypropylene (PP)	PP Corrugated Pipe With A Smooth Interior	ASTM F2736 (6"-30")

501.23.2. Materials.

501.23.2.1. PVC. The storm water conduit/drainpipe shall be of PVC compound having a minimum cell classification of 12454 in accordance with ASTM D1784 Rigid Poly (Vinyl Chloride) (PVC) Compounds and Chlorinated Poly (Vinyl Chloride) (CPVC) Compounds. The fittings shall be made of PVC compound having a cell classification of 12454 or 13343 as defined in ASTM D1784.

501.23.2.2. PE. The tube/pipe and fittings shall be made of virgin polyethylene which conforms with the requirements of cell class 335400C as defined and described in ASTM D3350 Polyethylene Plastics Pipe and Fittings Materials.

501.23.2.3. PP. Polypropylene compound for pipe and fitting production shall be impact modified copolymer meeting the material requirements of ASTM F2736, Section 4 for the respective diameters. Minimum pipe stiffnesses at 5% deflection shall meet or exceed ASTM F2736, Section 6.2.6 Pipe Stiffness.

501.23.3. Stiffness.

501.23.3.1. PVC. Constant minimum pipe stiffness at five-percent deflection shall be 46-psi for storm conduit as specified for all sizes when calculated in accordance with ASTM D2412 Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading.

501.23.3.2. PE. Minimum tube/pipe stiffness at 5-percent deflection shall be 50-psi for 3-in. through 10-in. diameters and as outlined in Section 7.4 of AASHTO M-294 for other diameters.

501.23.3.3. PP. Minimum pipe stiffnesses at 5% deflection shall meet or exceed ASTM F2736, Section 6.2.6 Pipe Stiffness.

501.23.4. Joints.

501.23.4.1. PVC. Joints shall be an integral bell-gasketed joint. When the joint is assembled, it shall prevent misalignment of adjacent pipes and form either a soil tight joint (2-psi hydrostatic test per AASHTO Standard Specification for Highway Bridges, Section 26.4.2.4) or a watertight joint (10.8-psi

test per ASTM D3212 Standard Specification for Joints for Drain and Sewer Plastic Pipes using Flexible Elastomeric Seals) as required.

501.23.4.2. PE. Joint integrity shall be tested in accordance with ASTM F667 Large Diameter Corrugated Polyethylene Pipe and Fittings, Section 9.6 for PE corrugated pipe up to 24" or AASHTO M-294 and M-252 for smooth-lined corrugated pipe. Profile wall HDPE pipe joints shall be made and tested in accordance with ASTM D3212 Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.

501.23.4.3. PP. Pipe shall be joined with a gasketed integral bell & spigot joint meeting the requirements of ASTM F2736 for the respected diameters (12”-30”), and shall be watertight according to the requirements of ASTM D3212. Gasket shall be installed by the pipe manufacturer and covered with a removable, protective wrap to ensure the gasket is free from debris. 12”-30” diameters shall have a reinforced bell with a polymer composite band installed by the manufacturer.

501.23.5. Testing.

501.23.5.1. PVC. Pipe shall be tested for flattening, impact resistance and extrusion quality as specified in the applicable ASTM Designations.

501.23.5.2. PE. All polyethylene tubing/piping shall be tested for elongation, brittleness, joint separation, quality and ring stiffness as specified in the applicable AASHTO M-294, AASHTO M-252 or ASTM F2648, as applicable.

501.23.5.3. PP. All polypropylene piping shall be tested as per ASTM F2736, Section 8 as applicable.

501.24. FIBERGLASS (GLASS-FIBER-REINFORCED THERMOSETTING-RESIN) WASTEWATER PIPE

501.24.1. General. This specification designates requirements for fiberglass glass-fiber reinforced thermosetting-resin pipe (RTRP) sizes from 8-in. to 144-in. for the conveyance of wastewater. Pipe for gravity application shall conform to ASTM D3262 for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Sewer Pipe. Pipe for force main applications shall conform to or ASTM D3754 for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Sewer and Industrial Pressure Pipe. If ASTM D3754 pipe is selected, its actual outside diameter shall be in accordance with AWWA C950 Fiberglass Pressure Pipe.

501.24.2. Stiffness. Minimum pipe stiffness at 5-percent deflection shall be 46-psi for gravity and pressure wastewater conduit and 36-psi for gravity sliplining applications as specified for all sizes when calculated in accordance with ASTM D2412 Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading.

501.24.3. Joints. Joint tightness shall be tested in accordance with ASTM D4161 for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe Joints Using Flexible Elastomeric Seals.

501.24.4. Fittings. Fittings shall conform to ASTM D5685 Fiberglass (Glass-Fiber-Reinforced Thermosetting-Resin) Pressure Pipe Fittings or D3840 Standard Specification for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe Fittings for Nonpressure Applications.

501.24.5. Testing. Pipe shall be tested for inside and outside diameter, wall thickness, squareness of pipe ends, chemical requirements, stiffness, beam strength as specified in the respective ASTM D3681 Test Method for Chemical Resistance of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe in a Deflected Condition, ASTM D2412 Standard Test Method for Determination of External Loading Characteristics of Plastic Pipe by Parallel-Plate Loading, and ASTM D3262 Standard Specification for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Sewer Pipe.

501.25. FIBERGLASS (GLASS-FIBER-REINFORCED THERMOSETTING-RESIN) FOR WATER PIPE

501.25.1. General. This specification designates requirements for glass-fiber reinforced thermosetting resin pipe in sizes 8-in. to 156-in. intended for water conveyance in pressurized systems of less than 450 psi. Pipe manufactured for these applications shall conform to ASTM D3517 Standard Specification for “Fiberglass” (Glass-Fiber-Reinforced Thermosetting-Resin) Pressure Pipe.

501.25.2. Joints. Joints shall either be bell & spigot with elastomeric gasket, flanged, lay-up lamination or mechanical coupling. Gaskets shall comply with ASTM F477 Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe. Lay-up laminations shall be of manufacturer approved materials and

applied by, or under, the supervision of a pipe manufacturer's representative. Mechanical coupling shall be of a type approved for use on the pipe by the manufacturer.

501.25.3. Fittings. Fittings shall conform to ASTM D5685 Standard Specification for Fiberglass (Glass-Fiber-Reinforced Thermosetting-Resin) Pressure Pipe Fittings. Only fittings approved for use by the pipe manufacturer shall be permitted.

501.25.4. Markings. All pipe shall have be clearly marked by the manufacturer designating nominal size, pressure class, stiffness, manufacturer's name or trademark, and ASTM D3517 Standard Specification for "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pressure Pipe.

501.25.5. Testing. All pipe and fittings, once in place complete with compacted backfilled shall be hydrostatically tested at 120-percent of design pressure in accordance with Section 506.5. Hydrostatic Test.

ITEM 504. OPEN CUT – BACKFILL

504.1. GENERAL

This section addresses the process of open cut and backfill. Backfill shall mean embedment and final backfill. Embedment shall mean bedding and initial backfill. Bedding shall mean the material upon which a pipe rests. Initial backfill shall mean material that covers the storm sewer, wastewater collection system, and water lines. Final backfill shall mean the material required to fill the trench from the top of the initial backfill to ground elevation or subgrade of a street.

Work shall include:

(1) Pollution Prevention shall be performed in accordance with Item 202. Temporary Erosion, Sedimentation, and Water Pollution Prevention and Control;
(2) Site preparation as part of open cut installation shall be performed in accordance with Item 203. Site Preparation, except shall be considered as incidental work and the cost thereof shall be included in such contract pay item as provided in the proposal and contract;
(3) Excavation shall be performed in accordance with Item 203.2. Unclassified Channel Excavation.
(4) Landscaping shall be performed in accordance with Item 204. Landscaping;
(5) Trench safety shall be performed in accordance with Item 107.20. Protection of Work and of Persons and Property;
(6) Restoration of disturbed areas shall be performed in accordance with Item 107.27. Restoration of Property.

504.2. MATERIALS

504.2.1. Pipe Embedment Material for Special Applications. The pipe shall be embedded in accordance with details shown on the plans for the type of embedment indicated or specified. In general, if no particular type of embedment is shown on the plans nor specified, CONTRACTOR shall use material according to pipe manufacturer recommendation.

504.2.2. Pipe Embedment Material for Storm, Water and Wastewater Mains.

504.2.2.1. Crushed Stone Embedment. The aggregates shall consist of durable particles of crushed stone, free from frozen material or injurious amounts of salt, alkali, organic matter or other material either free or as adherent coating, and its quality shall be reasonably uniform throughout. It shall have a wear of not more than 40-percent when tested in accordance with TxDOT Test Method Tex-410-A Abrasion of Coarse Aggregate Using the Los Angeles Machine.

When tested by standard laboratory methods, crushed stone embedment for each gradation shall meet the requirements of Table 504.2.2.1.(a) Crushed Stone Embedment Gradations.

Table 504.2.2.1.(a) Crushed Stone Embedment Gradations

Passing or Retained on Sieve	Percent by Weight
Standard Crushed Stone — Aggregate Grade 4	
Retained on 1½-in. sieve	0%
Retained on 1-in. sieve	0 to 5%
Retained on ½-in. sieve	40 to 75%
Retained on No. 4 sieve	90 to 100%
Retained on No. 8 sieve	95 to 100%
Blended Crushed Stone — Aggregate Grade 48	
Retained on 1½-in. sieve	0%
Retained on 1-in. sieve	0 to 5%
Retained on ½-in. sieve	40 to 75%
Retained on No. 4 sieve	75 to 100%
Retained on No. 8 sieve	90 to 100%
Fine Crushed Stone — Aggregate Grade 8	
Retained on ½-in. sieve	0%
Retained on ⅜-in. sieve	0 to 5%
Retained on No. 4 sieve	35 to 60%
Retained on No. 8 sieve	90 to 100%
Coarse Crushed Stone	
Passing 1½-in. sieve	100%
Retained on ¾-in. sieve	100%

504.2.2.2. Granular Material. Granular material shall be free flowing, such as sand or hydraulically graded crushed stone fines, or mixed sand and gravel, or sandy loam. The material shall be free from lumps, stones over two inches in diameter, clay and organic matter.

504.2.2.3. Select Material. Select material shall be gravel, fine stone cuttings, sand, sandy loam or loam free from excessive clay. Stone cuttings shall have no dimension greater than two-inches.

504.2.2.4. Crushed Stone for Foundation. Crushed stone for foundation shall meet the requirements for Item 504.2.2.1. Crushed Stone Embedment except the gradation shall be according to Table 504.2.2.4.(a) Crushed Stone for Foundation Gradation.

Table 504.2.2.4.(a) Crushed Stone for Foundation Gradation

Passing or Retained on Sieve	Percent by Weight
Passing 5-in. sieve	100%
Retained on 2-in. sieve	100%

504.2.2.5. Natural Gravel. Natural gravel shall consist of uncrushed stones meeting the requirements for wear as outlined in Item 504.2.2.1. Crushed Stone Embedment. The material shall be washed and screened and not have by weight more than one-percent organic matter, clays or loam and not more than five-percent by weight of any one of or combination of slate, shale, schist or soft particles of sandstone. The gradation shall be according to Table 504.2.2.5. (a) Natural Gravel Gradation.

504.2.2.6. Sand. Sand shall consist of clean, hard, durable, uncoated grains, free from lumps and organic material. All particles must pass a No. 8 sieve.

504.2.3. Final Backfill. The trench shall be backfilled in accordance with details shown on the plans for the type of backfill indicated or specified.

If filter fabric is required by OWNER, place filter fabric conforming to TxDOT Specification DMS-6200 between the native soil and the backfill.

504.2.3.1. Type "A" Backfill. Type "A" backfill shall meet the following requirements:

504.2.3.1.1. Tests. The liquid limit shall not exceed 35 when tested in accordance with ASTM D4318 Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils. The plasticity index shall not exceed 10 when calculated in accordance with ASTM D4318. The linear shrinkage shall not exceed six-percent when Type "A" backfill is used for pavement base material.

504.2.3.1.2. Gradation. The material when tested by standard laboratory methods shall meet the gradation in Table 504.2.3.1.2.(a) Type "A" Gradation.

Table 504.2.3.1.2.(a) Final Backfill Type "A" Gradation

Passing or Retained on Sieve	Percent by Weight
Passing 2-in. sieve (50 mm)	100%
Passing ½-in. sieve (12.5 mm)	50 to 85%
Passing No. 4 sieve (4.75 mm)	20 to 65%
Passing No. 100 sieve (150 um)	0 to 5%

504.2.3.2. Alternate Allowable Type "A". Field sand having the following requirements may be used in lieu of Type "A" backfill for filling trenches. The field sand material shall be obtained from approved sources; shall consist of durable particles; and shall be free of thin or elongated pieces, lumps of clay, soil, loam or vegetable matter. The material shall be required to meet the gradation in Table 504.2.3.2.(a) Alternate Allowable Type "A" Gradation when tested from source of supply test samples.

Table 504.2.3.2.(a) Alternate Allowable Type "A" Gradation

Passing or Retained on Sieve	Percent by Weight
Passing No. 4 sieve (4.75 mm)	100%
Passing No. 16 sieve (1.18 mm)	80 to 100%
Passing No. 50 sieve (300 um)	20 to 60%
Passing No. 100 sieve (150 um)	10 to 40%
Passing No. 200 sieve (75 um)	0 to 10%

504.2.3.3. Type "B" Backfill. Type "B" backfill is native or imported material. Type "B" backfill shall at minimum meet the following quality requirements.

504.2.3.3.1. Tests. The liquid limit shall not exceed 35 when tested in accordance with ASTM D4318. The plasticity index shall not exceed 12 when tested in accordance with ASTM D4318.

504.2.3.3.2. Gradation. Type "B" backfill shall meet the requirements in Table 504.2.3.3.2.(a) Final Backfill Type "B" Requirements.

Table 504.2.3.3.2.(a) Final Backfill Type "B" Requirements

Description	Limits
Stone. All stone must be reasonably uniform in distribution throughout the backfill material in order to be considered acceptable for use, regardless of the width of trench in which the material is to be used.	
Maximum amount of stone permitted, regardless of trench width, as a percent of final backfill volume	50%
Largest dimension of stone allowed in trenches 4-ft. or less in width	3-in.
Largest dimension stone to total final backfill volume, regardless of trench width	3%
Largest dimension of stone allowed in trenches greater than 4 ft. in width	6-in. Total volume not to exceed 1% of backfill
Lumps. All lumps must be reasonably uniform in distribution throughout the backfill material in order to be considered acceptable for use, regardless of the width of trench in which the material is to be used	
Maximum amount of clay or gumbo lumps permitted, regardless of trench width, as a percent of final backfill volume	25%
Largest dimension of clay or gumbo lumps in trenches 4-ft. or less in width	6-in.
Largest dimension of clay or gumbo lumps permitted in trench greater than 4-ft. in width.	10-in. Total volume not to exceed 1% of backfill

504.2.3.3.3. Additional Requirements. Additional requirements for Type "B" backfill when used in streets:

(1) 35 percent or less shall pass the No. 200 sieve.
(2) Material otherwise meeting specifications requirements and having a PI greater than 15 shall be considered as suitable for use only when compaction procedure includes mechanical compaction.
(3) Material shall be of such characteristics that it shall stabilize without the use of lime or other similar additive and form an acceptable street subbase material.

504.2.3.4. Flowable or Stabilized Backfill. Flowable or stabilized backfill shall consist of a mixture of native soils or manufactured materials, cement and/or fly ash, and water which produces a material with unconfined compressive strength of between 250-psi and 450-psi after 28-days. Any materials used shall be primarily granular, with a plasticity index <12 and with 100% passing a ¾-in. sieve. The flowable mixture shall be mixed in a pug mill, concrete mixer, or transit mixer and shall have a minimum slump of 5-in. The flowable mixture must be allowed to set prior to the placement of any overlying material. Stabilized backfill as defined in Item 504.6.2. Stabilized Backfill requires manual compaction.

504.2.3.5. Modified Flowable Backfill. Modified flowable backfill in areas of possible future excavation such as utility installations shall consist of a mixture of native soils or manufactured materials, cement and/or fly ash, air-entraining material, and water which produces a material with unconfined compressive strength of between 50-psi and 150-psi after 28-days. Modified flowable backfill in permanent areas such as abandoned pipe closures, abutments and embankments shall contain similar materials and shall have an unconfined compressive strength of greater than 150-psi after 28 days. Any materials used shall be primarily granular, with a plasticity index <12 and with 100% passing a ¾-in. sieve. The flowable mixture shall be mixed in a pug mill, concrete mixer, or transit mixer and shall have a minimum slump of 5-in. The flowable mixture must be allowed to set prior to the placement of any overlying material.

504.2.3.6. Fast Set Flowable Backfill. Fast Set Flowable Backfill shall be brought to site via volumetric concrete mixer and consist of an appropriate amount of cement (with other additives as necessary) mixed with mortar sand to flow and fill all voids in the excavation. This fill shall develop a compressive strength of 1120 pounds per square foot one hour after placement, and a 28-day compressive strength with the range of 25 to 100 psi. The material must be such that it can be capped in one and one-half to two hours.

504.2.4. Rejection. Materials that fail to meet the requirements of these specifications may be rejected by the OWNER. Such rejection shall incur no cost to the OWNER. Material sources, from which materials with properties not meeting these specifications are delivered, may be rejected as further supply sources to the project by the OWNER. Such rejection shall incur no cost to the OWNER.

504.3. EXCAVATION AND FOUNDATION

504.3.1. Excavation. Excavation shall be performed in accordance with Item 203. Site Preparation.

504.3.2. Foundation. During the progress of the work, should the foundation for the conduits be in material unsuitable for the subgrade of the conduit, which is not the result of the CONTRACTOR'S negligence to make proper provisions for adequate drainage of the excavation, the CONTRACTOR shall remove such unsuitable subgrade material to the depth directed by the OWNER. The space thus created shall be filled with stone as described in Item 504.2.2.4. Crushed Stone for Foundation, coarse crushed stone as described in Item 504.2.2.1. Crushed Stone Embedment, or Class B or Class PB concrete (as specified by the OWNER) as described in Item 702.3. Mix Design and Mixing Concrete for Structures. The type of material to be used for the foundation shall be determined by the OWNER. In lieu of removing the subgrade material or in conjunction with placement of the foundation material, the OWNER may require a geotextile material as described in the contract documents to be placed between the bedding and the subgrade or between the foundation material and the subgrade.

The entire foundation area in the bottom of all excavation shall be firm, stable and at uniform density as nearly as practicable. Unless necessary, materials shall not be disturbed. The final cleaning off and preparing of the foundation area shall be done immediately prior to the placing of the embedment materials or structures.

504.3.2.1. Foundation Measurement. Foundation material shall be measured for payment complete in place to the dimensions prescribed by the OWNER. Geotextile material, if used, shall be measured for payment complete in place to the dimensions prescribed by the OWNER.

504.3.2.2. Foundation Payment. Foundation material shall be paid for at the contract unit bid price in cubic yards as provided for in the contract. Geotextile material shall be paid for at the contract unit bid price per square yard as provided for in the contract. If a bid item is not established in the contract for foundation material and/or geotextile material, it shall be considered subsidiary to the contract (non-pay item).

In case of failure to make adequate pumping, draining and bailing provisions, resulting in unstable subgrade conditions, and which shall require any of the hereinbefore described foundations, such foundations shall be placed at the entire cost of the CONTRACTOR and shall not be measured or paid for as separate contract pay items.

The contract unit price shall be total compensation for furnishing all labor, tools, materials, equipment and incidentals necessary to complete the work, including all excavation and disposal of surplus material.

504.4. BACKFILL – GENERAL REQUIREMENTS

504.4.1. Description. This specification shall govern construction of all types of storm drain, wastewater collection systems, and water structures except where the requirements are revised by another governing specification. All structures shall be constructed in accordance with the design requirements, with the details shown on the plans, and with the requirements herein provided. Other applicable sections or parts of these specifications shall govern for such miscellaneous and incidental construction necessary to complete the work in accordance with the plans and specifications.

For specific applications, pipe materials, etc. refer to Section 504.5.2. Embedment Classes.

504.4.2. Materials and Equipment. All materials used in the construction of work specified in this division shall conform to the applicable sections of these specifications and approved by the OWNER. Any materials placed before approval of the OWNER shall be removed, if directed by the OWNER, and replaced with approved materials.

All machinery and equipment necessary for the construction of the work specified herein shall be on the project and shall be maintained in good condition to insure the completion of the work without excessive delays for repairs and replacements. Equipment used for disposal of surplus materials beyond the limits of the work shall be such as to avoid spilling or wasting of materials along the line of haul. The CONTRACTOR shall immediately clean up all materials spilled or wasted along the line of haul. The OWNER reserves the right to approve the location and methods of disposal for surplus material.

504.4.2.1. Water for Construction. Unless otherwise specified in the contract, water required for construction and furnished from the OWNER'S distribution system shall be paid and accounted for as prescribed by the OWNER. The CONTRACTOR shall make and bear the cost of all necessary arrangements and means for hauling the water. Water shall be furnished free of charge from the OWNER'S main, if available, for filling newly constructed water mains for flushing, sterilizing and hydrostatic testing. Construction water, if delivered through a fire hydrant meter, shall be protected by a reduced pressure zone assembly provided at the CONTRACTOR'S expense.

504.4.2.1.1. Use of Fire Hydrant and Valves. The CONTRACTOR shall not operate any fire hydrant or valve in the existing water system without the permission of the OWNER. If permission is granted, the CONTRACTOR shall use only approved fire hydrant and valve wrenches. The OWNER shall inspect all fire hydrants and/or valves operated by the CONTRACTOR prior to final acceptance of the project. All repairs or replacements required to restore satisfactory operation of fire hydrants and/or valves shall be at the expense of the CONTRACTOR.

504.4.2.2. Material and Equipment Storage. The CONTRACTOR shall confine equipment, storage of materials, and construction operations to the area shown on the Contract Drawings or as directed by OWNER. Storage shall not unreasonably encumber the site or public right-of-way with construction equipment or materials. Materials shall be stored in a manner to best protect and preserve the material to the satisfaction of the OWNER. Materials shall be sorted and stored neatly and accessibly. Materials not properly stored shall not be eligible for inclusion in partial pay estimates. Storage shall also comply with all requirements of Item 106. Control of Material.

504.4.3. Sequence. The sequence of operations to be followed shall be prepared by the CONTRACTOR for approval by the OWNER. The sequence shall meet the job requirements for completion time, avoid interference with plant operations and conform to plan and specification requirements. The construction of all storm drain and wastewater collection systems shall begin at the outlet or lower end, unless otherwise directed by the OWNER. Tributary lines for storm drain and wastewater collection systems shall not be started until the main line has been built to their junction points.

504.4.4. Connections. The connections of conduits or appurtenances to conduits shall be made in accordance with the plans and as directed by the OWNER. This work shall be done in such a manner so as not to damage any of the structures involved. Any damage to the structures due to the connection shall be repaired at the CONTRACTOR'S expense. No connecting conduit shall project beyond the inside surface of other conduits or appurtenances, except in case of pipe laid through a manhole.

504.5. EMBEDMENT

Embedment is the bedding and initial backfill. The type of embedment to be used for storm water collection systems, wastewater collection systems or water mains shall be specified in the contract documents or on the plans.

504.5.1. General

504.5.1.1. Terms.

D — Inside diameter of the pipe.

OD — Outside diameter of the pipe.

B_c — Outside diameter of the pipe.

B_d — Trench width.

Stone cuttings are rock trench excavated material. The maximum allowable dimension of the stone to be used for embedment is 1-in.

Densities shall be shown as a percent of the maximum dry density at not less than 2% below optimum moisture of samples of the material as determined by the ASTM D698 Maximum Density Optimum Moisture Test.

504.5.1.2. Flexible Pipe. 16-in. or greater diameter flexible pipe may be strutted horizontally and vertically prior to backfilling. After backfilling, the struts shall be removed and the deflection checked to verify that excessive deflection as specified has not occurred. If excessive deflection has occurred, the pipe shall be removed and reinstalled.

504.5.1.3. Trench Dimensions. Trench dimensions shall be determined according to Table 504.5.1.3.(a) Trench Dimensions unless otherwise specified as greater.

Table 504.5.1.3.(a) Trench Dimensions

Pipe size	Trench Dimensions
Minimum Depth of Trench Below the Pipe	
27-in. and smaller	3-in.
30-in. to 60-in.	4-in.
66-in and larger	6-in.
Limiting Trench Width	
24-in. pipe and smaller	24-in. or O.D. of the pipe plus 16-in., whichever is greater
Greater than 24-in., to and including 72-in.	O.D. of the pipe installed plus 24-in.
Larger than 72-in.	O.D. times 1.25 plus 1-ft.

504.5.2. Embedment Classes.

504.5.2.1. Class "A" Embedment. See Standard Drawing 3010. The embedment consists of concrete bedding and initial backfill of granular material.

After the trench has been cut to a depth below the barrel of the pipe a distance of ¼B_c, minimum of 6 in. measured from the outside of the pipe bell, the pipe shall be laid to grade on supporting brick or concrete block and jointed as specified. A compressible strip shall be placed between the pipe and the support. The pipe shall be restrained, if required, to prevent flotation. Class B or Class PB concrete as specified by the OWNER shall be poured on either side of the pipe to form the bedding under the pipe and up the sides of the pipe ¼B_c. The concrete placed under the pipe shall have a sufficient fluidity so it can flow under the haunches and be puddled to insure even support.

The initial backfill layer shall be granular material and shall be brought to a point 12-in. above the top of the pipe.

504.5.2.2. Class "A-1" Embedment. See Standard Drawing 3010. The embedment consists of crushed stone bedding and a cap of concrete as initial backfill.

After the trench has been cut to a depth below the barrel of the pipe a distance of ¼B_c, minimum of 6 in. measured from the outside of the pipe bell, the bedding layer shall be brought to a point slightly above grade with compacted standard gradation crushed stone. Bell holes shall be formed, if required, a trough scooped out to grade, and the pipe laid and jointed as specified. The stone shall then be brought up in uniform layers on either side of the pipe ½B_c.

Class B or Class PB concrete as specified by the OWNER, plain or reinforced as specified in the plans, shall be poured over the top of the pipe and bells to cover the pipe with a thickness of ¼B_c, 4-in. minimum to form the initial backfill layer.

504.5.2.3. Class "B" Embedment. See Standard Drawing 3020. The embedment consists of crushed stone bedding and initial backfill of select material or granular material.

After the trench has been cut to a depth below the barrel of the pipe a distance of ⅛B_c, minimum of 6 in. measured from the outside of the pipe bell, the bedding shall be brought up to a point slightly above the grade with stone cuttings or crushed stone, standard gradation. Bell holes shall be formed, a trough scooped out to grade and the pipe laid and joined as specified. The crushed stone or stone cuttings shall then be brought up the sides of the pipe in uniform layers ½B_c.

The initial backfill shall consist of granular material. The material shall be placed on top of the crushed stone in uniform layers on either side of the pipe to a point 12 in. above the top of the pipe and compacted to at least 90-percent of maximum density as determined by ASTM D698.

504.5.2.4. Class "B+" Embedment. See Standard Drawing 3020. The embedment consists of fine crushed stone bedding and initial backfill of granular material.

After the trench has been cut to a depth below the barrel of the pipe a distance of ⅛B_c, minimum of 6 in. measured from the outside of the pipe bell, the bedding shall be brought up to a point slightly above grade with fine crushed stone. Bell holes shall be formed, a trough scooped out to grade and the pipe laid and jointed as specified. The stone shall then be brought up in uniform layers on either side of the pipe ½B_c.

The initial backfill shall consist of granular material. The material shall be placed on top of the stone and shall be brought up in uniform layers on either side of the pipe to a point 12-in. above the top of the pipe. Density shall be at least 90-percent of maximum density as determined by ASTM D698.

504.5.2.5. Class "B-1" Embedment. See Standard Drawing 3020. The embedment consists of fine crushed stone bedding and initial backfill of select material or granular material.

After the trench has been cut to a depth below the barrel of the pipe a distance of ⅛B_c, minimum 6 in. for measured from the outside of the pipe bell, the bedding shall be brought up to a point slightly above grade with fine crushed stone. Bell holes shall be formed and the pipe laid and jointed as specified.

The stone shall then be brought up in uniform layers on either side of the pipe ¾B_c.

The initial backfill shall consist of compacted granular material brought up to a point 6 in. above the top of the pipe. Density shall be at least 90-percent of maximum density as determined by ASTM D698.

504.5.2.6. Class "B-2" Embedment. See Standard Drawing 3030. The embedment consists of fine crushed stone bedding and initial backfill of select material or granular material.

After the trench has been cut to a depth below the barrel of the pipe 6 in. measured from the outside of the pipe bell, the bedding layer shall be brought to a point slightly above grade with compacted fine crushed stone. Bell holes shall be formed, if required, a trough scooped out to grade, and the pipe laid and jointed as specified. The stone bedding layer shall then be brought up in uniform layers on either side of the pipe ¾B_c.

The initial backfill shall consist of compacted granular material and shall be brought to a point 12 in. above the top of the pipe. Density shall be at least 90-percent of maximum density as determined by ASTM D698.

504.5.2.7. Class "B-3" Embedment. See Standard Drawing 3030. The embedment consists of granular material.

After the trench has been cut to a depth below the barrel of the pipe a distance of minimum of 6 in. measured from the outside of the pipe bell, the bedding shall be brought to a point slightly above grade with compacted fine sand. Bell holes shall be formed, if required, a trough scooped out to grade, and the pipe laid and jointed as specified. The granular material shall then be brought up in uniform layers on either side of the pipe and over the pipe to a point 12 in. above the top of the pipe.

504.5.2.8. Class "B-4" Embedment. See Standard Drawing 3030. The embedment consists of cement-treated backfill.

After the trench has been cut to a depth below the barrel of the pipe a distance of minimum of 6 in. measured from the outside of the pipe bell, the bedding shall be brought to a point slightly above grade with cement-treated backfill. Bell holes shall be formed, if required, a trough scooped out to grade and the pipe laid and jointed as specified. The cement-treated backfill shall then be brought up to uniform layers on either side of the pipe and over the pipe to a point 6 in. above the top of the pipe.

504.5.2.9. Class "C" Embedment. See Standard Drawing 3040. The embedment is a bedding of crushed stone or stone cuttings and initial backfill of select material or granular material.

After the trench has been cut to a depth below the barrel of the pipe a distance of $\frac{1}{8}B_c$, minimum of 6 in. measured from the outside of the pipe bell, the bedding shall be brought up to a point slightly above grade with stone cuttings or standard crushed stone. Bell holes shall be formed, a trough scooped out to grade, and the pipe laid and jointed as specified. The stone shall then be brought up in uniform compacted layers on either side of the pipe $^1/_6B_c$.

The initial backfill shall be granular material and shall be brought up in uniform compacted layers to a point 6 in. above the top of the pipe. Density shall be at least 90-percent of maximum density as determined by ASTM D698.

504.5.2.10. Class "C+" Embedment. See Standard Drawing 3040. The embedment consists of fine crushed stone bedding and initial backfill of granular material.

After the trench has been cut to a depth below the barrel of the pipe a distance of $\frac{1}{8}B_c$, minimum of 6 in. measured from the outside of the pipe bell, the bedding layer shall be brought up to a point slightly above grade with fine crushed stone. Bell holes shall be formed, a trough scooped out to grade, and the pipe laid and jointed as specified. The stone shall then be brought up in uniform, compacted layers on either side of the pipe $^1/_6B_c$.

The initial backfill shall be granular material and shall be brought up in uniform, compacted layers to a point 6 in. above the top of the pipe. Density shall be at least 90-percent of maximum density as determined by ASTM D698.

504.5.2.11. Class "C-1" Embedment. See Standard Drawing 3040. The embedment shall consist of fine sand bedding and initial backfill of granular material.

After the trench has been cut to a depth below the barrel of the pipe a distance of $^1/_8B_c$ minimum of 6 in. measured from the outside of the pipe bell, the bedding layer shall be brought up to a point slightly above grade with fine sand. Bell holes shall be formed, a trough scooped out to grade and the pipe laid and jointed as specified. The sand shall then be brought up in uniform compacted layers on either side of the pipe $^1/_6B_c$.

The embedment backfill shall be granular material and shall be brought up in uniform, compacted layers to a point 6-in. above the top of the pipe. Density shall be at least 90-percent of maximum density as determined by ASTM D698.

504.5.2.12. Class "D+" Embedment. See Standard Drawing 3050. The embedment consists of select material.

After the trench has been cut to a depth below the barrel of the pipe a distance of $\frac{1}{8}B_c$, minimum of minimum of 6 in. measured from the outside of the pipe bell, the embedment shall be brought up to a point slightly above grade with select material. Bell holes shall be formed, a trough scooped out to grade and the pipe laid and jointed as specified. The material shall then be brought up in uniform compacted layers to a point 6 in. over the top of the pipe. Density shall be at least 90-percent of maximum density as determined by ASTM D698.

504.5.2.13. Class "G" Embedment. See Standard Drawing 3050. The embedment consists of Class B or Class PB concrete as specified by the OWNER.

After the trench has been cut to a depth below the barrel of the pipe a distance of $\frac{1}{4}B_c$, 6 in. minimum measured from the outside of the pipe bell, the pipe shall be laid and jointed as specified. The pipe shall be supported by brick or concrete block. A compressible strip shall be placed between the pipe and support. The pipe shall be restrained, if required, to prevent flotation. Class B or Class PB

concrete as specified by the OWNER shall be poured on either side of the pipe to form the embedment under the pipe, up the sides and over the top of the pipe and bells with a minimum thickness of 6 in. The concrete placed under the bell shall have a sufficient fluidity so it can flow under the haunches and be puddled to insure even support.

504.5.2.14. Class "G-1" Embedment. See Standard Drawing 3060. The embedment consists of Class "G" embedment as specified above and a trench backfill of Class B or Class PB concrete as specified by the OWNER or stabilized backfill, whichever is specified in the plans, and a 6 in. thick Class B or Class PB (as specified by the OWNER) concrete cap as initial backfill.

504.5.2.15. Class "H" Embedment. See Standard Drawing 3060. The embedment consists of a completely encased pipe with standard Crushed Stone, Grade 4. After the trench has been cut to a depth below the barrel of the pipe a distance of $\frac{1}{8}B_c$, 6 in. minimum, the bedding layer shall be brought to a point slightly above grade with compacted crushed stone. Bell holes shall be formed, a trough scooped out to grade and the pipe laid and jointed as specified. The material shall then be brought up in uniform compacted layers of 6 in. to a point 6 in. over the top of the pipe.

504.5.2.16. Alternate Embedment for Concrete Pipe. The Engineer may design alternate embedment for concrete pipe. Such embedment shall be designed according to Design Data 40, Standard Installations and Bedding Factors for the Indirect Design Method written by the American Concrete Pipe Association. Such embedment shall be constructed as shown on the plans.

504.5.3. Initial Backfill.

504.5.3.1. General. Initial backfill is the material that covers the storm drain system, wastewater collection system, and water lines. Backfill procedure is that procedure required to return trenches or excavated areas to a condition satisfactory to the OWNER. Such backfilling occurs in two general areas. They are: (1) areas not subject to vehicular traffic; and (2) areas subjected directly to, or influenced by, vehicular traffic.

The methods of backfilling to be used shall vary with the width of trench, the character of the materials excavated, the method of excavation, the type of conduit and the degree of compaction required. The placing of backfill shall not begin until the pipe structure has been properly bedded and jointed and until approval has been given by the OWNER. The excavation shall be backfilled only with approved material.

504.5.3.2. Compaction. Compaction of all backfill material shall be performed in a manner that shall not crack, crush and/or cause the installed pipe to be moved from the established grade and/or alignment, as shown on the plans. Satisfactory density shall be obtained at various depths on all backfill material as indicated from random selected test points prior to the required exfiltration or pressure tests that are to be performed on lines being constructed. The required moisture content shall be at not less than 2% below nor more than 4% above the optimum moisture of the material or as specified by the OWNER. In-place density/moisture content shall be tested and verified as specified by the OWNER, or at a minimum frequency of once per 300-linear-feet per 1-foot of compacted depth.

504.5.3.2.1. Densities — Areas Subjected To or Influenced by Vehicular Traffic. The trench backfill shall be mechanically compacted to the top of the subgrade in 6-in. loose lifts to at least 95-percent of maximum density as determined by ASTM D698 Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lb/ft^3). The embedment shall be compacted by a method approved by the OWNER to a density as specified under the description of the embedment as outlined in Item 504.5. Embedment.

504.5.3.2.2. Densities — Areas Not Subjected To or Influenced by Vehicular Traffic. The trench backfill shall be placed in layers not more than 10-in. loose depth and shall be compacted by mechanical means, subject to the restrictions outlined in Item 504.5.3.2.5. Compaction Methods to at least 90-percent of maximum density as determined by ASTM D698. The embedment shall be compacted by a method approved by the OWNER to a density as specified under the description of the embedment required as outlined in Item 504.5. Embedment.

504.5.3.2.3. Special Situations. In areas specifically designated in the plans and specifications, the entire backfill shall be backfilled and compacted to the density specified.

504.5.3.2.4. Limitations. Densities as specified shall be obtained as the project progresses. No more than 75-percent of the pipe installation on the project is to be completed until specified compaction and density requirements have been ascertained on backfill material for at least 25-percent of the pipe laid, or until an approval to proceed with pipe installation has been given by the OWNER.

504.5.3.2.5. Compaction Methods. The method of compaction shall be left to the discretion of the CONTRACTOR with the following exception, unless otherwise specified, provided the degree of compaction is obtained and provided that the pipe is not damaged in the process. If any potential damage to the pipe due to a method of compaction exists, in the opinion of the OWNER, that method of compaction shall not be allowed.

Compaction of any backfill material by flooding or jetting shall not be permitted.

Hand-operated mechanical tampers may be used with approval of the OWNER for compacting backfill.

504.5.3.3. Rejection. If the backfill does not meet the specified density and optimum moisture requirements throughout its depth, the OWNER shall require its removal and replacement to meet the above requirements at the CONTRACTOR'S expense.

504.6. FINAL BACKFILL

Final backfill material is the material required to fill the trench from the top of the initial backfill to ground elevation or subgrade of a street.

504.6.1. Excavated Material. Excavated material may be used in the trench backfill, provided (1) it meets the requirements of Item 504.2.3.3. Type "B" backfill, and (2) the material is approved for backfill by the OWNER.

504.6.2. Stabilized Backfill. Stabilized backfill shall consist of a mixture of native soils including the trench excavation, approved for use by the OWNER, and two sacks of cement per cubic-yard. All material shall be mixed in a concrete mixer or transit mix unless approved otherwise by the OWNER. The stabilized backfill shall be compacted in a moist condition or water added to provide a free flowing mixture. If a free flowing mixture is used, the initial set must be permitted prior to placement of any material on the surface of the stabilized backfill.

504.6.3. Concrete Backfill. Concrete backfill shall consist of selected stone material or granular material mixed with a minimum of two sacks of cement per cubic-yard. All material shall be mixed in a concrete mixer or transit mixed unless approved otherwise by the OWNER.

504.6.4. Granular Material Backfill. Granular material backfill shall meet the requirements of Item 504.2.2.2. Granular Material.

504.6.5. Sand Backfill. Sand backfill shall meet the requirements of Item 504.2.2.6. Sand.

504.6.6. Flowable Backfill. Flowable backfill shall meet the requirements of Item 504.2.3.4. Flowable Backfill.

504.6.7. Modified Flowable Backfill. Modified flowable backfill shall meet the requirements of Item 504.2.3.5. Modified Flowable Backfill.

504.6.8. Fast Set Flowable Backfill. Fast Set Flowable Backfill shall meet the requirements of Item 504.2.3.6. Fast Set Flowable Backfill.

504.7. MEASUREMENT AND PAYMENT OF BACKFILL

504.7.1. Measurement of Backfill Material. Measurement of backfill, which includes embedment and final backfill, shall be made per linear-foot of pipe only if a separate bid item is established in the Contract.

504.7.2. Payment of Backfill Material. Payment for backfill shall be made at the contract unit price per linear-foot of pipe only if a separate bid item is established in the Contract. This shall include furnishing and placing all materials and for all labor, tools, equipment and incidentals necessary to complete the work, all in accordance with the plans and specifications. No allowance for waste shall be made.

504.7.2.1. Special Embedment. If the OWNER orders an embedment material other than that specified in the Contract, it shall be paid for as an extra in price per linear foot of pipe, as compacted in place, except if another class embedment is ordered by the OWNER because the CONTRACTOR has over-excavated the trench width.

If the CONTRACTOR over-excavates the trench width and the OWNER orders another class of embedment to be used, the embedment shall be paid per linear-foot of pipe, compacted in place for the embedment originally specified if the original embedment was specified to be paid as a separate bid item. In lieu of another class of embedment, the CONTRACTOR may elect to use another class pipe if approved by the OWNER. The pipe shall be paid for as specified in relevant Items of Division 500 Underground Conduit Construction and Appurtenances at the unit price per linear-foot for the pipe originally specified if the original pipe was specified to be paid as a separate bid item.

If the CONTRACTOR elects to use another class embedment and the use of the embedment is approved by the OWNER, but not directed by the OWNER, the embedment shall be paid per linear-foot of pipe, compacted in place for the embedment originally specified if the original embedment was specified to be paid as a separate bid item.

504.7.2.2. Final Trench Backfill. If the CONTRACTOR elects to use a material other than the excavated material as trench backfill and the use of the material is approved by the OWNER, but not directed by the OWNER, the material shall be furnished and placed at no cost to the OWNER. The excavated material shall be disposed of at no cost to the OWNER.

If the OWNER orders the excavated material to be removed and disposed of and replaced with another material and a separate bid item is not established, the material shall be paid as an extra. The disposal of the rejected excavated material shall be at no cost to the OWNER.

If the OWNER orders the excavated material to be removed and disposed of and replaced with another material because of neglect of the CONTRACTOR to properly remove or store the material, or if the CONTRACTOR fails to compact the excavated material in the trench to the density requirements and the OWNER orders the material removed, the excavated material shall be replaced with a material approved by the OWNER at no cost to the OWNER. The disposal of the rejected material shall be at no cost to the OWNER.

504.7.2.3. Trench Safety. Payment for trench safety shall be according to the provisions of Item 107.20. Protection of Work and of Persons and Property.

ITEM 508. OPEN CUT – STORMWATER CONDUIT INSTALLATION

508.1. DESCRIPTION

This item shall govern and control the furnishing and placing of culvert pipe and/or conduits or drainage lines, including pipe fittings, connecting drain lines to curb inlets, all joints, all connections to new or existing pipe or headwalls, manholes, catch basins etc., to the lines and grades shown on the plans. All pipe and fittings shall be of the types, shapes, classes, sizes and dimensions as shown thereon; and as may be required to complete the work as shown on the plans.

508.2. GENERAL

508.2.1. Excavation, Embedment, and Backfill. All excavation, pipe embedment, and backfill shall conform to the relevant requirements of Item 504. Open Cut – Backfill, with modifications specified herein.

508.2.2. Trenchless Installation. Where tunneling or jacking methods are shown on the plans or permitted by the OWNER, methods shall conform to the requirements of Item 503. Trenchless Installation.

508.3. REINFORCED CONCRETE PIPE AND BOX FOR STORMWATER

This item shall govern and control the furnishing and placing of reinforced concrete storm water collection system.

508.3.1. Materials. Reinforced concrete pipe and jointing materials shall conform to the requirements of Item 501.6. Reinforced Concrete Culvert, Storm Drain, Pipe and Box Section.

508.3.2. Installation.

508.3.2.1. Pipe. All activities shall be in compliance with ASTM C1479. Bedding and backfill shall be as described in Item 504. Open Cut - Backfill. The CONTRACTOR shall furnish, at its own expense, and place in position as directed by the OWNER all necessary batter boards, string lines, plummets, graduated poles, lasers, etc., required in establishing and maintaining the lines and grades. The batter boards and all location stakes must be protected from possible damage or change of location.

All pipe and fittings shall be laid and jointed in a dry trench.

Unless otherwise authorized, start the laying of pipe on the bedding at the outlet end with the spigot or tongue end pointing downstream, and proceed toward the inlet end with the abutting sections properly matched, true to the established lines and grades. Fit, match, and lay the pipe to form a smooth, uniform conduit. Where bell-and-spigot pipe is used, cut cross trenches in the foundation to allow the barrel of the pipe to rest firmly upon the bedding. Do not cut cross trenches more than 2 in. larger than the bell ends of the pipe. Lower sections of pipe into the trench without damaging the bedding and the sides of the trench. Carefully clean the ends of the pipe before the pipe is jointed. Prevent the earth or bedding from entering the pipe when it is laid. Fill all lifting holes with plugs.

The bedding grade under the middle third of the pipe outside diameter shall be prepared before laying the pipe section. Making adjustments in grade by exerting force on the barrel of the pipe with excavating equipment, by lifting and dropping the pipe, or by lifting the pipe and packing bedding material under it shall be prohibited. If the installed pipe section is not on grade, the pipe section shall be completely unjoined, the grade corrected, and the pipe then rejoined.

When elliptical pipe with circular reinforcing or circular pipe with elliptical reinforcing is used, the pipe shall be laid in the trench in such a position that the markings “top” or “bottom” shall not be more than 5° from the vertical plane through the longitudinal axis of the pipe.

508.3.2.2. Box. All activities shall be in compliance with ASTM C1675. Bedding and backfill shall be as described in Item 504. Open Cut - Backfill. When precast boxes are used to form multiple barrel structures, place the box sections in conformance with the plans or as directed. Place material to be used between barrels as shown on the plans or as directed. Unless otherwise authorized, start the laying of boxes on the bedding at the outlet end and proceed toward the inlet end with the abutting sections properly matched. Fit, match, and lay the boxes to form a smooth, uniform conduit true to the established lines and grades. For trench installations, lower the box sections into the trench without damaging the box or disturbing the bedding and the sides of the trench. Carefully clean the ends of the box before it is placed. Prevent the earth or bedding material from entering the box as it is laid. Proper facilities and equipment shall be provided for hoisting and lowering the box sections without disturbing

the leveling course and the sides of the excavation or damaging the box section. Proper equipment, such as a come-along or puller, should be utilized to join the sections together. Remove and re-lay, without extra compensation, boxes that are not in alignment or that show excessive settlement after laying. Unless otherwise approved by the OWNER, loads from construction equipment transferred to a box before, during, or after fill placement, either directly or through the fill, shall not be greater than the loads assumed in the design.

508.3.3. Jointing. Jointing shall be one of the following types: Cold applied preformed plastic gaskets, flexible joint sealant, expanded cellular gaskets, or rubber gaskets. Jointing materials shall conform to the requirements of Item 501.6.1.3. Joints. Gasket installation practices shall be in accordance with the manufacturer's recommendations.

508.3.3.1. Cold Applied Preformed Plastic Gaskets or Flexible Joint Sealant (Mastic). If required by OWNER, a suitable primer of the type recommended by the manufacturer of the gasket joint sealer may be brush applied to the tongue-and-groove joint surfaces and the end surfaces and allowed to dry and harden. No primer shall be applied over mud, sand or dirt or sharp cement protrusions. The surface to be primed must be clean and dry when primer is applied. Primer that shows cracking or flaking at time of installation shall not be accepted.

Before laying the pipe in the trench, attach the plastic gasket sealer around the tapered tongue or tapered groove near the shoulder or hub of each pipe joint. Remove the paper wrapper from one side only of the two-piece wrapper on the gasket and press it firmly to the clean, dry pipe-joint surface. The outside wrapper is not to be removed until immediately before pushing the pipe into its final position.

When the tongue is correctly aligned with the flare of the groove, remove the outside wrapper on the basket and pull or push the pipe home with sufficient force and power (backhoe shovel, chain hoist, ratchet hoist or winch) to cause the evidence of squeeze-out of the gasket material on the inside or outside around the complete pipe joint circumference. Remove any joint material that pushed out onto the interior of the pipe that would tend to obstruct the flow. Pipe shall be pulled home in a straight line with all parts of the pipe on line and grade at all times. Pipe damaged by this operation shall be subject to review by the OWNER and, if necessary, a change in the jointing procedure may be required. Backfilling of pipe laid with plastic gasket joints may proceed as soon as the joint has been inspected and approved by the OWNER. Special precautions shall be taken in placing and compacting backfill to avoid damage to the joints.

When the atmospheric temperature is below 60°F, plastic joint seal gaskets shall either be stored in an area warmed to above 70°F, or artificially warmed to this temperature in a manner satisfactory to the OWNER. Gaskets shall then be applied to pipe joints immediately prior to placing the pipe in the trench, followed by connection to previously laid pipe.

Refer to ASTM C990 Standard Specification for Joints for Concrete Pipe, Manholes, and Precast Box Sections Using Preformed Flexible Joint Sealants.

508.3.3.2. Flexible Cellular Materials. Joints using flexible cellular gaskets do not need to be primed. If they are primed, be certain the primer is cured and non-tacky before installing gaskets.

The CONTRACTOR shall provide a copy of the manufacturer's installation instructions to the OWNER. Just before laying the pipe in the trench, stretch the gasket around the tapered tongue (or wedge it into the tapered groove) near the shoulder or hub of each pipe joint. Treat these low-tensile gaskets gently when handling. When the tongue is correctly aligned with the flare of the groove, pull or push home with sufficient force and power (winch, ratchet hoist, chain hoist or backhoe shovel) to compress the gasket to the extent that the joint gap falls within the recommended range around the entire pipe joint circumference.

CAUTION: Do not close the joint flush, or completely flatten the gasket.

Joint gap ranges for each gasket size are shown in Table 508.3.3.2.(a) Joint Gap Ranges.

Table 508.3.3.2.(a) Joint Gap Ranges

Gasket Sizes as Printed on Parts	Joint Gap Range	
	Minimum	Maximum
3/8″ x 3/8″	3/8″	3/4″
1/2″ x 3/8″	3/8″	7/8”
3/4″ x 3/8″	3/8″	1”
1/2″ x 1/2″	1/2″	1-1/8”
3/4″ x 1/2″	1/2″	1-1/4”
7/8″ x 1/2″	1/2″	1-1/4”
1-1/8″ x 1/2″	1/2″	1-3/8”
1/2″ x 3/4″	3/4″	1-1/2”
5/8″ x 3/4″	3/4″	1-1/2”
3/4″ x 3/4″	3/4″	1-5/8”
7/8″ x 3/4″	3/4″	1-5/8”

508.3.3.3. Rubber Gaskets.

(1) Ensure that bell and spigot are free from cracks, chips, and other defects.
(2) Brush loose dirt and debris from the inside surface of the bell, the spigot, and the gasket.
(3) Stretch the gasket around the spigot, with the nose against the step, and the tube lying flat against the spigot.
(4) If not self-lubricating, apply manufacture recommended water-based lubricant on the gasket and bell.
(5) Align the spigot with the bell, ensuring that the gasket is in contact with the bell around the complete periphery, then thrust pipe home using suitable manual or mechanical means.

508.3.4. Fittings.

508.3.4.1. Poured Concrete Pipe Collars. At all changes in pipe sizes in the conduit line, except at manholes, a pipe collar, as shown in detail on the plans, shall be provided. The locations at which such collars are to be provided are shown on the plan-profile sheets, and their costs are to be included in the price bid for furnishing and installing reinforced concrete pipe. No extra payment shall be made for the installation of concrete pipe collars as shown on the plan-profile sheets.

508.3.4.2. Shop and Field Fabricated Wyes, Tees, Crosses and Bends. Shop or field fabricated wyes, tees, crosses or bends shall be furnished and installed where indicated or required by the OWNER. Fittings for pipe, the largest size of which is less than 24-in. in diameter, shall be shop fabricated. Fittings for larger pipe, which is 24-in. in diameter and increasingly larger, may be field fabricated. Care shall be taken in the fabrication that the concrete walls of the pipe are broken back only enough to provide the required finishing opening. The reinforcing mesh or bars in each pipe shall be joined by bending, twisting or spot welding, which shall provide a rigid connection. Concrete or mortar meeting the requirements of Item 303. Portland Cement Concrete Pavement or Item 702. Concrete Structures shall be wiped over the reinforcing wires connecting the two-pipe joints, compacted by light blows, shaped to the contour of the pipe barrels, lightly brushed for finish and cured under wet burlap.

508.3.4.3. Poured Concrete Pipe Plugs. When conduit lines terminate at locations which do not include connection to drainage structures, the end of the pipe shall be plugged with a field-cast unit as shown on the plan-profile sheets, and the costs thereof are to be included in the price bid to furnish and install reinforced concrete pipe. No extra payment shall be made for the installation of concrete pipe plugs as shown on the plan-profile sheets.

508.4. CORRUGATED METAL PIPE

This item shall govern and control the furnishing and placing of corrugated metal storm water collection system.

508.4.1. Pipe Materials. Unless otherwise specified on the plans or required herein, corrugated metal pipe may be aluminum, galvanized steel, aluminized steel, or precoated galvanized or aluminized steel. Pipe

shall be full circle or pipe arch type as shown on the plans. Damage to materials incurred prior to backfilling shall be corrected according to Item 501.11.7. Repairs.

508.4.2. Couplings. Materials shall conform to the requirements of Item 501.11.9. Couplings. Joints shall prevent infiltration of side material during the life of the installation. Connecting bands shall be placed with the clamping angles and bolts at the tops of the pipe. When it is necessary to join a new pipe of helical corrugations to an existing pipe which was installed with no circumferential end corrugations, the two pipes shall be field jointed with helically corrugated bands.

508.4.3. Excavation of Backfilling. In addition to the requirements of Item 508.2.1. Excavation, Embedment, and Backfill, the provisions contained herein apply.

When pipes are laid in a trench, the trench when completed and shaped to receive the pipe shall be of sufficient width to provide free working space for satisfactory bedding and jointing and thorough tamping of the backfill and bedding material under and around the pipe.

Backfilling for the metal pipe structures is a critical phase of the construction and strict adherence of Item 504. Open Cut – Backfill is required. Unless otherwise shown on the plans or permitted in writing by the OWNER, no heavy earth moving equipment will be permitted to haul over the structure until a minimum of 4-ft. of permanent or temporary, compacted fill has been placed thereon. Until a minimum cover over pipe of 12-in. is obtained, only hand operated tamping equipment will be allowed within vertical planes 2-ft. beyond the horizontal projection of the outside surfaces of the structure. Prior to adding each new layer of loose backfill material, until a minimum of 12-in. of cover is obtained, an inspection will be made of the inside periphery of the structure for local or unequal deformation caused by improper construction methods. Evidence of such will be reason for such corrective measures as may be directed by the OWNER. OWNER may require CONTRACTOR to remove and replace pipe damaged by the CONTRACTOR'S backfilling operation at no additional cost to the OWNER.

508.4.4. Laying Corrugated Metal Pipe. Unless otherwise authorized by the OWNER, the laying of pipes on the prepared foundation shall be started at the outlet end, and separate sections firmly joined together, with outside laps of circumferential joints pointing upstream and with longitudinal laps on the sides. Any metal in joints which is not protected by galvanizing or aluminizing shall be coated as approved by the OWNER. Proper facilities shall be provided for hoisting and lowering the sections of pipe in to the trench without damaging the pipe or disturbing the prepared foundation and the sides of the trench. Any pipe which is not in alignment or which shows any undue settlement after laying, or is damaged, shall be taken up and re-laid without extra compensation.

Multiple installations of corrugated metal pipe and pipe arches shall be laid with the center lines of individual barrels parallel. Unless otherwise indicated on the plans, the clear distances between outer surfaces of adjacent pipes listed in Table 508.4.4.(a) Clear Distances shall be maintained.

Table 508.4.4.(a) Clear Distances

Diameter of Pipe	Clear Distance Between Pipes Full Circle and Pipe Arch	Pipe Arch
18-in.	1-ft. 2-in.	21-in. x 15-in.
24-in.	1-ft. 5-in.	28-in. x 20-in.
30-in.	1-ft. 8-in.	35-in. x 24-in.
36-in.	1-ft. 11-in.	42-in. x 29-in.
42-in.	2-ft. 2-in.	49-in. x 33-in.
48-in.	2-ft. 5-in.	57-in. x 38-in.
54-in.	2-ft. 10-in.	64-in. x 43-in.
60-in.	3-ft. 2-in.	71-in. x 47-in.
66-in.	3-ft. 2-in.	77-in x 52-in.
72-in. through 84-in.	3-ft. 2-in.	—
90-in. through 120-in.	3-ft. 5-in.	—

508.4.5. Connections. Where new structures are constructed as extensions to structures in place or are jointed to existing structures, the construction shall include all work necessary to provide a proper connection between the new structure and the old as indicated on the plans, including coating of the connection when required.

508.4.6. Reuse of Existing Headwalls. When existing headwalls and aprons are specified on the plans for reuse, the portion to be reused shall be severed from the existing pipe and moved to the new position previously prepared, by approved methods.

Connections shall conform to the requirements for joining sections of pipes as indicated herein or as shown on the plans. Any headwalls, aprons or pipe attached to the headwall damaged during moving operations shall be restored to their original condition at the CONTRACTOR'S expense. The CONTRACTOR, if it so desires, may remove and dispose of the existing headwalls and aprons and construct new headwalls at its own expense, in accordance with the pertinent specifications and design indicated on the plans or as furnished by the OWNER.

508.5. STRUCTURAL PLATE CONDUIT

This work shall consist of furnishing and installing structural plate conduit of standard or special shapes conforming to these specifications of the sizes, out dimensions, the minimum gage or thickness of metal, footing design, if required, and material required by plans, at the places designated on the plans or by the OWNER, in conformity with established lines and grades.

508.5.1. Materials.

508.5.1.1. Structural Plates. The plates used for construction of structural plate conduits shall conform to the specifications in Item 501.12. Structural Plate Structures.

508.5.1.2. Concrete. Concrete, curing and reinforcing steel shall conform to Item 702. Concrete Structures. Unless otherwise shown on the plans, concrete for footings and headwalls shall be Class A or Class PA as specified by the OWNER. Concrete for longitudinal stiffeners (thrust beams), when specified for steel structures, shall be Class B or Class PB as specified by the OWNER and shall be reinforced in accordance with the plans. Concrete used in longitudinal stiffeners (thrust beams) on steel structures shall cure a minimum of 3-days before backfilling against or over the stiffener. Riprap for slope protection and for invert paving, when required, shall be Class B or Class PB concrete as specified by the OWNER, with reinforcement as specified on the plans and shall conform to the requirements of Item 803.3. Riprap.

508.5.2. General Construction Methods. Structural plate conduits shall be constructed from the specified materials in accordance with the plans and this item.

Steel plates will have approximately a 2-in. lip beyond each end crest, which results in the actual length of a given structure being approximately 4-in. longer than the nominal length, except when skewed or beveled. Footings for arches shall be designed and constructed to accommodate this additional length.

The distance between multiple structures shall be shown on the plans with the minimum distance being that space required to permit adequate compaction of backfill material.

508.5.3. Excavation. Unless otherwise required, all structural excavation shall be in accordance with the requirements of Item 701.2. Structural Removal, Excavation, and Backfill, and the additional requirements herein. The excavation will be of sufficient width to provide ample working space for erection and proper compaction of backfill and bedding material. The CONTRACTOR shall provide adequate drainage of the cut and bedding during the construction operation.

If the quality of the native soil is as good as or better than the proposed backfill material, excavation shall be to the limits set forth in the Item 701.2. Structural Removal, Excavation, and Backfill. If the quality of the native soil is less than that of the proposed backfill material, the excavation shall extend, from each side of the barrel, a minimum horizontal distance of ½-span or $^{2}/_{3}$-rise, whichever is greater.

508.5.4. Substructures for Structural Plate Arches. The substructure for structural plate arches shall be as detailed on the plans. Concrete footings, when required, shall be placed entirely on either rock or firm soil. When footing area is partially rock and partially soil, the rock shall be removed below grade and replaced with suitable materials so that a slightly yielding, compacted earth cushion is provided below the

footing for a minimum of 12-in. When a thin layer of soil is partially covering rock within the bearing area and when practical to do so, the soil may be removed and the footings placed directly on rock in accordance with details shown on the plans.

Footings shall be formed and finished to true lines and grades as established by the OWNER. Anchors or slots shall be set to true line and grade when placing concrete for each substructure unit. No plates for arch structures shall be placed until the substructure has cured for a minimum of 3-days.

Any portion of an aluminum structure that is in contact with a metal other than aluminum or in contact with concrete containing chlorides shall be insulated from this other metal or concrete containing chlorides by a coating of bituminous material or a plastic coating, such as asphalt, mastic or polymeric coating. The coating shall be applied to the aluminum structure to provide insulation between the aluminum and other metal or concrete containing chlorides and shall extend a minimum distance of 1-foot beyond the area of contact.

508.5.5. Foundations for Structural Plate Conduits with Metal Inverts. Horizontal ellipses, box culverts, or other structural plate shapes with metal inverts shall be placed on a shaped bed of granular material carefully and accurately shaped to fit the lower part of the structure for at least 10-percent of its overall height, except that the length of bedding arc need not exceed the width of the bottom plate. The granular material shall be at least 3-in. in thickness, so as to obtain uniform seating of the corrugations on the structure bed. For culverts, the bedding specified herein shall be the full width of the invert. Where rock, in either ledge or boulder formation, is encountered, it shall be removed below grade and replaced with a compacted earth cushion having a thickness of not less than ½-in.-per-foot height of fill over the top of the structure, with the minimum allowable thickness of 12-in. and a maximum of 24-in. under the structure. Where the soil encountered at the established grade is a quicksand, muck or similar unstable material, it shall be removed and replaced in accordance with the requirements of Item 701.2. Structural Removal, Excavation, and Backfill.

508.5.6. Skewed Structures. The end skew shall not exceed 45°. When the skew of arches is more than 15°, the length of the structure shall be such that no portion of the live load will be carried by the cut portion of the arch end. Where right-of-way or other conditions do not permit the required length, the cut end shall be supported by a rigid headwall designed to meet the conditions. When the skew angle of pipes exceeds 20° and the structure has the ends cut to fit a slope, the ends shall be reinforced with concrete riprap or other suitable end treatment as indicated on the plans or as directed by the OWNER. If headwalls are required, the plates shall be anchored to the headwall with not less than ¾-in. diameter by 6-in. minimum length bolts, at not over 19-in. centers. If structures are to have skewed ends, bevels, step-bevels or other special end treatment, this information will be shown on the plans.

508.5.7. Erection and Shape Control. When all plates of a structure are in position, all bolts not already in place shall be inserted and all nuts tightened progressively and uniformly, beginning at one end of the structure. All nuts shall be tightened a second time to a torque of not less than 150-ft.-lbs. nor more than 300-ft.-lbs. for steel structures, and not less than 125-ft.-lbs. nor more than 150-ft.-lbs. for aluminum structures.

It is essential that bolts be well tightened. If an impact wrench is used, a sufficient number of bolts shall be checked with a long-handled, structural or socket wrench or torque wrench to insure that they are properly tightened. All service bolts used in drawing the plates together shall be replaced with standard high strength bolts.

Lateral ties, struts and/or false-work may be required on some structures to maintain proper shape and alignment during erection and backfill operations. Monitoring of the structure shape throughout erection and backfill requires careful observations of the symmetry and uniform curvature of the periphery of the structure. If there is any tendency toward loss of symmetry in shape or loss of curvature in the structure periphery, even though the structure is within the tolerances stated herein, construction involving the structure shall cease until a proper course of action is established.

CONTRACTOR shall furnish acceptable devices for monitoring the horizontal and vertical shape of the structure. For box culverts and structures not requiring longitudinal or transverse stiffeners, the shape shall be kept within 2-percent of design measurements (span or rise, whichever is greater) or 5-in., whichever is less, during erection and backfilling. For structures requiring either longitudinal stiffeners or transverse

stiffeners (except box culverts), a minimum of 5 monitoring devices shall be furnished at transverse sections, with one at each longitudinal stiffener, one at the top of the structure, and one at each mid span of the top arc. These shall be installed at each end and as a minimum on 24-ft. increments for the entire structure length.

For the shape factor furnished (shape factor = Rt/Rs, where Rt is the radius of the top arc and Rs is the radius of the side arc), unless otherwise shown on the plans, the allowable sag from design shape during erection, as a percentage of the rise shall not exceed tolerances shown in Table 508.5.7.(a) Allowable Sag.

Table 508.5.7.(a) Allowable Sag

Shape Factor	Allowable Sag (expressed as percentage of the rise)
up to 2.74	4%
2.75 through 3.24	2%
3.25 and greater	1%

Shape shall be checked at least after each two, 1-ft. compacted lifts of backfill, with the upward movement of the top of the structure during backfilling, not to exceed 2-percent of the rise, nor more than 50-percent loss of the mid-ordinate of the side plates, nor more than 25-percent deviation of any mid-ordinate of the top plates, all measured from the design shape. Selective top loading of the structure may sometimes be required to prevent distortion in excess of tolerances given herein.

508.5.8. Backfilling. Backfilling and/or construction of the embankment around and over the structure is a critical phase of the construction, and strict adherence to these construction methods is required. Backfilling and/or embankment construction around the structure shall be performed in accordance with Item 203. Site Preparation and Item 504. Open Cut – Backfill, except as modified herein.

Any damage to plates or structures caused by equipment and/or backfilling operations shall be corrected or removed and replaced to the OWNER'S satisfaction at the entire expense of the CONTRACTOR.

508.5.8.1. Structural Plate Conduits Without Longitudinal or Transverse Stiffeners and Box Culverts. Unless otherwise shown on the plans or permitted in writing by the OWNER, no heavy earth moving equipment will be permitted to haul over the structure until a minimum of 4-ft. of permanent or temporary compacted fill has been placed thereon. Within vertical planes 2-ft. beyond the horizontal limits of the structure and until a minimum of 2-ft. of cover has been compacted over the structure, only hand operated, mechanical tamping equipment will be permitted.

During the backfilling operations, extreme care shall be taken to avoid unequal pressures and to obtain uniformly compacted backfill material of uniform density throughout the length of the structure and to insure proper backfill under the structure.

The structure shall be backfilled so that when backfill is complete, the inside dimensions shall be within tolerances set forth in Item 508.5.7. Erection and Shape Control. Backfill material will be placed and compacted in maximum 8-in. lifts simultaneously along each side of the structure until the height of the backfill has reached the crown of the structure. Backfill shall continue to be placed in maximum 12-in. lifts over the crown in layers extending laterally from the crown and compacted using hand operated or light compaction equipment until the design height is obtained.

For multiple structures the same backfill phases will be performed for all structures more or less simultaneously. Backfilling between the barrels will usually require that the material be placed with a crane and bucket or other suitable equipment. Backfill material shall not be dropped from a height or concentrated in such an amount prior to distribution over the top arc that damage to the flexible structure will result. Compaction of this backfill shall be with hand operated tampers or other acceptable equipment.

508.5.8.2. Structural Plate Conduits Requiring Longitudinal or Transverse Stiffeners Except Box Culverts. The plans will designate, when appropriate, the longitudinal stiffener designs for steel structures or a transverse stiffener design for aluminum structures. The backfill material to be used adjacent to and over the structure to the minimum required cover (as shown on the plans) shall be a

granular type material such as a well graded sand and gravel (preferably sharp, rough and angular if possible), or a uniform sand or gravel. Plastic soils will not be permitted. The structure backfill material shall conform to one of the following soil classifications as defined in Table 508.5.8.2.(a) Classification of Soils and Soil-Aggregate Mixtures.

(1) For height of fill less than 12-ft.: A-1, A-3, A-2-4 and A-2-5 may be used.
(2) For height of fill of 12-ft. or greater: A-1 and A-3 may be used.

Table 508.5.8.2.(a) Classification of Soils and Soil-Aggregate Mixtures

GENERAL CLASSIFICATIONS = GRANULAR MATERIALS (35-Percent or Less Passing No. 200)					
Characteristic	**Group Classification**				
	A-1		**A-3**	**A-2**	
	A-1-a	**A-1-b**		**A-2-4**	**A-2-5**
Sieve Analysis, Percent Passing:					
(No. 10)	50 max.	—	—	—	—
(No. 40)	30 max.	50 max.	51 max.	—	—
(No. 200)	15 max.	25 max.	10 max.	35 max.	35 max.
Characteristics of Fraction Passing 0.425 mm. (No. 40)					
Liquid limit	—		—	40 max.	41 min.
Plasticity index	6 max.		N. P.	10 max.	10 max.
Usual Types of Significant Constituent Materials	Stone Fragments, Gravel and Sand		Fine Sand	Silty or Clayey Gravel and Sand	

The backfill material shall be compacted to at least 95-percent of maximum density as determined by ASTM D698 Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3). Moisture content shall be within minus-2- to plus-4-of-optimum. It may not be possible to develop this compacted density in the first lift of material over the top arc (Phase 2 described below) due to the influence of the flexible structure; therefore, density in at least the first lift over the top arc (Phase 2) will be the highest density attainable using equipment authorized herein.

The backfill pattern and sequence, up to at least the depth of minimum required cover, shall be in three phases. Phase 1 of the backfill operation will be to backfill under the haunches and/or along the side-walls of the structure. Backfill material will be placed in maximum 8-in. lifts simultaneously along each side of the structure until the height of backfill has reached the top of the longitudinal stiffeners or that longitudinal seam (edge of structure crown where the top arc plates connect to the side arc plates).

Phase 2 will be to work simultaneously symmetrically from both sides of the structure with light track type equipment pushing material over the crown until three 12-in. lifts of backfill have been placed and compacted uniformly over the crown. The light track equipment shall not exceed 20,000-pounds gross weight with a track pressure less than 1700-pounds-per-square-foot.

After the crown has been uniformly covered, Phase 3 will be to continue to place maximum 12-in. lifts of backfill, compacted, which extend laterally from the crown and compact over the crown and at the sides of the structure using hand operated or light tractor drawn compaction equipment working at the same time on each side of the structure at the same longitudinal location, until at least the minimum required depth of cover is attained. Wheel type equipment will not be allowed over the crown of the structure until Phase 3 is complete.

For multiple structures the same backfill phases will be performed for all structures more or less simultaneously. Backfilling between the barrels will usually require that the material be placed with a crane and bucket or other suitable equipment. Backfill material shall not be dropped from a height or concentrated in such an amount prior to distribution over the top arc that damage to the flexible structure will result. Compaction of this backfill shall be with hand operated tampers or other acceptable equipment.

508.6. CORRUGATED THERMOPLASTIC PIPE

This item shall govern and control the furnishing and placing of corrugated thermoplastic pipe to be used in storm water collection systems.

508.6.1. Pipe Materials. Unless otherwise specified on the plans or as required herein, corrugated thermoplastic pipe shall meet the requirements of Item 501.23. Thermoplastic Corrugated Drainage Tubing and Corrugated Smooth Lined Storm Water Pipe and Fittings. Pipe shall be full circle as shown on the plans. Damage to the materials incurred prior to backfilling shall be removed and replaced.

508.6.2. Couplings. Materials shall conform to the requirements of Item 501.23.4. Joints shall prevent infiltration of side material during the life of the installation. Soil-tight Joints shall be bell and spigot or utilize couplings that engage at least two full corrugations on each pipe section in accordance with AASHTO M330.

508.6.3. Installation of Pipe. The CONTRACTOR shall furnish, at its own expense, and place in position as directed by the OWNER all necessary batter boards, string lines, plummets, graduated poles, lasers, etc., required in establishing and maintaining the lines and grades. The batter boards and all location stakes must be protected from possible damage or change of location. The cost of replacement of location stakes shall be at no additional cost to the OWNER.

All pipe and fittings shall be laid and jointed in a dry trench of a minimum width as shown in Table 508.6.3.(a) Minimum Trench Widths for the Installation of Corrugated Thermoplastic Pipe.

The minimum depth of cover and trench width should be established by the OWNER based on evaluation of specific project conditions or ASTM D2321.

Table 508.6.3.(a) Minimum Trench Widths for the Installation of Corrugated Thermoplastic Pipe

Nominal Inside Pipe Diameter (Inches)	Typical Outside Pipe Diameter (inches)			Minimum Trench Width[1] (Inches)
	HDPE	PP	PVC	
4	4.9	NA	4.3	21
6	6.9	NA	6.4	23
8	9.1	NA	8.6	25
10	11.2	NA	10.8	27
12	14.3	14.5	12.8	30
15	17.5	17.6	15.7	33
18	21.5	21.2	19.2	38
24	28.0	28.0	25.6	46
30	35.5	35.4	32.2	55
36	42.0	41.1	38.7	63
42	47.5	47.2	NA	71
48	54.0	53.8	NA	79
54	61.0	NA	NA	88
60	67.0	66.5	NA	95

[1]For pipe sizes larger than those shown above, use pipe manufacturer's recommendation or ASTM D2321.

Install foundation and bedding as required by the OWNER. Unless otherwise authorized by the OWNER, the laying of the pipe on the prepared foundation shall be started at the outlet or downstream end with the spigot or tongue end of the pipe joint pointing downstream. Place pipe and fittings in the trench with the invert conforming to the required elevations, slopes, and alignment. Place embedment materials by methods that will not disturb or damage the pipe. Work in and tamp the haunching material in the area between the bedding and the underside of the pipe before placing and compacting the remainder of the embedment in the pipe zone.

Laying shall proceed toward the inlet or upstream end with each abutting section of pipe properly matched, true to the established lines and grades. Approved facilities shall be provided for hoisting and lowering the sections of pipe or the sides of the trench. The ends of the pipe shall be carefully cleaned before the pipe is placed in the trench. As each length of the pipe is laid, the open end shall be protected to prevent

the entrance of earth or bedding material. The pipe shall be fitted and matched so that when laid in the prepared bedding, it shall form a smooth, uniform conduit.

508.6.4. Jointing. Jointing shall be one of the following types: Soil-tight joints shall meet the requirements of Item 501.23.4. Joints; Water-tight Joints shall meet the requirements of Item 501.23.4. Joints. The CONTRACTOR is to comply with manufacturer's recommendations for assembly of joint components, lubrication, and making of joints.

508.6.5. Excavation and Backfilling. In addition to the requirements of Item 504. Open Cut – Backfill, the provisions contained herein apply.

When pipes are laid in a trench, the trench when completed and shaped to receive the pipe shall be of sufficient width to provide free working space for satisfactory bedding and jointing and thorough tamping of the backfill and bedding material under and around the pipe. Backfilling for thermoplastic pipe structures is a critical phase of the construction and strict adherence of Item 504. Open Cut – Backfill is required. Unless otherwise shown on the plans or permitted in writing by the OWNER, no heavy earth moving equipment will be permitted to haul over the structure until a minimum of 2 feet of depth for 24 inch diameter and smaller pipes or a minimum of 3 feet on pipes larger than 24 inches in diameter of permanent or temporary, compacted fill has been placed thereon. Until a minimum cover over pipe of 12 inches is obtained, only hand operated tamping equipment will be allowed within vertical planes 2 feet beyond the horizontal projection of the outside surfaces of the structure. Prior to adding each new layer of loose backfill material, until a minimum of 12 inches of cover is obtained, an inspection will be made of the inside periphery of the structure for local or unequal deformation caused by improper construction methods. Evidence of such will be reason for such corrective measures as may be directed by the OWNER. OWNER may require CONTRACTOR to remove and replace pipe damaged by the CONTRACTOR'S backfilling operation at no additional cost to the OWNER.

508.6.5.1. Shaping and Bedding. Bed the pipe in a foundation of compacted cohesionless material, such as sand, crushed stone, or pea gravel, with a maximum allowable size of 1 in. Extend this material a minimum of 6 in. below the outermost corrugations or ribs, and carefully and accurately shape it to fit the lowest part of the pipe exterior for a minimum of 10% of the overall height. When requested by the OWNER, furnish a template for each size and shape of pipe to be placed for use in checking the shaping of the bedding. Provide a template consisting of a thin plate or board cut to match the lower half of the cross section of the pipe.

508.6.5.2. Backfilling. Backfill from the pipe bedding up to 1 ft. above the top of the pipe to provide necessary structural support to the pipe and control pipe deflection. Take special precautions when placing and compacting backfill material. Place special emphasis obtaining uniform compacted density throughout the length of the pipe, to avoid unequal pressure. Use extreme care to ensure proper backfill under the pipe, in the haunch zone.

Provide backfill material meeting the following specifications:

(1) Type I- Provide backfill consisting of flowable fill in accordance with Item 504.2.3.4 Flowable Backfill. Place the flowable backfill across the entire width of the trench and maintain a minimum depth of 12 in. above the pipe. Wait a minimum of 24 hours before backfilling the remaining portion of the trench with other backfill material in accordance with Item 504.2.3. Final Backfill.

(2) Type II- Provide backfill consisting of cement stabilized backfill in accordance with Item 504.2.3.5. Modified Flowable Backfill. Place and compact cement stabilized backfill to completely fill any voids.

(3) Type III- Provide backfill consisting of hard, durable, clean granular material that is free of organic matter, clay lumps, and other deleterious matter. Provide backfill meeting the gradation requirement shown in Table 508.6.5.2.(a). Place the backfill material along both sides of the completed structure to a depth of 12 in. above the pipe. Place the backfill in uniform layers a minimum of 6 in. deep (loose measurement), wet if required and thoroughly compacted between adjacent structures and between the structure and the sides of the trench. Until a minimum cover of 12 in. is obtained, only hand-operated tamping equipment will be allowed within vertical planes 2 ft. beyond the horizontal projection of the outside surfaces of the structure. If using Type III backfill,

place filter fabric between the native soil and the backfill as directed by OWNER. Filter fabric shall meet TxDOT Specification DMS-6200.

Table 508.6.5.2.(a) Gradation Requirements for Type III Backfill Material

Sieve Size	Percent Retained (Cumulative)
1 in.	0-5
7/8 in.	0-35
1/2 in.	0-75
3/8 in.	0-95
No. 4	35-100
No. 10	50-100
No. 200	90-100

508.6.6. Pipe Testing. Upon completion of pipe installation, the CONTRACTOR shall test thermoplastic and thermoset pipe for deflection. Deflection tests shall be performed no sooner than 30-days after densification of backfill.

Deflection testing shall be performed by the CONTRACTOR at no cost to the OWNER. No payment will be made for delays that result from the CONTRACTOR's performance of deflection testing.

The CONTRACTOR shall test all thermoplastic pipes for deflection by one of the following methods: 1. Mandrel, or 2. Laser Video.

Nominal diameter 27-in. or smaller shall be tested by mandrel. The mandrel shall be pulled through the pipe by hand to ensure that maximum allowable deflections have not been exceeded. Pipe with nominal ID larger than 27-in. may be tested by an alternate method as approved by the OWNER. If a mandrel is selected to test pipe 27-in. and larger, the minimum diameter, length and other requirements shall conform to the dimensions and requirements as stated below. Deflection measurement for ID's nominally larger than 27-in. shall be determined using a 1-in. diameter rigid, nonadjustable metal bar approved by the OWNER; a minimum-radius rigid template; or by a method approved by the OWNER.

508.6.6.1. Mandrel. Prior to use, the mandrel shall be certified by the OWNER. Mandrel requirements are as follows:

(1) odd-number of legs with 9 legs minimum
(2) effective length not less than its nominal diameter
(3) fabricated of steel
(4) fitted with pulling rings at each end
(5) stamped or engraved on some segment other than a runner indicating the pipe specification, nominal size, and mandrel OD

If the mandrel fails to pass, the pipe shall be considered to be "overdeflected". Any overdeflected pipe shall be uncovered and, if not damaged, reinstalled. Damaged pipe shall not be reinstalled, but shall be removed and replaced. Any pipe subjected to any method or process other than removal, which attempts, even successfully, to reduce or cure any overdeflection, shall be uncovered, removed and replaced with new pipe. Final remediation to be approved by OWNER.

508.6.6.2. Laser Video Equipment. A combination color CCTV pipeline survey system with a cable distance counter, laser profiling system, non-contact video micrometer and measurement software shall be used to perform a measurement survey of thermoplastic pipelines with nominal inside diameter 60-in. or smaller. The equipment used shall be certified by a recognized independent testing group and includes a certified accuracy of 0.5% or better and a repeatability of 0.12% or better. Refer to ASTM E691 and ASTM E177 for equipment calibration.

508.6.7. Multiple Installations of Corrugated Thermoplastic Pipe. Multiple installations of corrugated thermoplastic pipe shall be laid with the center lines of individual barrels parallel. Unless otherwise indicated on the plans, the clear distances between outer surfaces of adjacent pipes are listed in Table 508.6.7.(a) Clear Distances shall be maintained.

The minimum clear distance should be established by the OWNER based on evaluation of specific project conditions or pipe manufacturer's recommendations.

Table 508.6.7.(a) Clear Distances

Diameter of Pipe (Inches)	Clear Distance Between Outside surfaces of Pipes – Full Circle (Inches)
18 and smaller	14 in.
24	17 in.
30	20 in.
36	23 in.
42	26 in.
48	29 in.
54	34 in.
60	38 in.
66	38 in.

508.7. MEASUREMENT AND PAYMENT FOR STORMWATER CONDUIT INSTALLATION

508.7.1. Measurement. Pipe, including corrosion protection, if in place on the pipe, or unless otherwise covered by a special bid item, shall be measured for payment in linear feet along the centerline of the pipe measured from centerline of manhole to centerline of manhole or to the end of the line in a case where no manhole exists. Deductions shall be made for special structures. Pipe which extends only through the wall of the structure shall be measured to the actual end of the pipe. No deductions shall be made for fittings, measurements being from center to center of fitting. Conduits shall not be classified for payment according to depth unless a separate trenching item is not included.

508.7.2. Payment. Pipe, including corrosion protection in place on the pipe, or unless otherwise covered by a separate bid item, shall be paid for at the contract unit price per linear foot, complete in place, as provided by the contract. The contract price per linear foot shall be the total compensation for furnishing of all labor, materials, tools, equipment, and incidentals necessary to complete the work in accordance with the plans and these specifications.

ITEM 509. CROSSINGS

509.1. GENERAL

This specification shall govern for the construction of underground conduits (water, wastewater, stormwater mains, etc.) on or across streets, alleys, highways or railroads, creeks or rivers as detailed in the plans. The CONTRACTOR shall provide and employ adequate warning signs, barricades, lights, watchmen, etc. to fully protect its workers and the traveling public as required in Item 107.20. Protection of Work and of Persons and Property and Item 107.19. Public Convenience and Safety. No changes shall be made in location as shown on the plans without prior authorization of the appropriate agency and the OWNER. Bore pits and related appurtenances are to comply with the requirements of the franchise owner. For crossings not mentioned below, the crossing requirements of the affected owner shall be followed.

509.2. STATE HIGHWAY CROSSINGS

All crossings shall conform to the TxDOT *Utility Accommodation Policy Manual Special Specifications*. Permits from TxDOT are required for all highway crossings. A copy of permits obtained from TxDOT shall be at the construction site available for the OWNER to review.

509.3. STREET AND ALLEY CROSSINGS

The construction of underground conduits on or across street and alley rights-of-way and the removal and replacement of pavement, curb and gutter, etc., shall be in accordance with the following requirements.

The CONTRACTOR shall protect the street and alley surface and all existing improvements from excavated materials, equipment operations and other construction operations. If jacking, boring or tunneling is indicated or specified, the work shall be performed in accordance with the requirements of Item 503. Trenchless Installation. If open-cut method is indicated or specified, the construction operations shall be conducted in accordance with the requirements in Item 504. Open Cut – Backfill.

509.4. RAILROAD CROSSINGS

All railroad crossings shall conform to the respective railroad company's requirements. The CONTRACTOR must obtain insurance and other requirements of the railroad company prior to beginning any work within the railroad right-of-way.

509.5. CREEK AND RIVER CROSSINGS

Creek crossing using pier construction shall be made in accordance with the details shown on the plans. River crossings, siphons and miscellaneous pipe structures as may be necessary shall be designed in detail on the plans.

509.6. MEASUREMENT AND PAYMENT OF CROSSINGS

Each crossing within the limits noted on the plans and/or set forth in the proposal shall constitute a separate pay item where indicated on the plans and specifications and shall be paid for as shown in the proposal. The contract price shall be the total compensation for the furnishing of all labor, materials, tools, equipment and incidentals necessary to complete the work, including all excavation, disposal of surplus materials and backfill, in accordance with the plans and these specifications. The contract price or combination of prices includes compensation for excavation for piers, erecting piers, stripping forms, erecting pipe and supporting pipe (if required), in accordance with the plans and specifications.

ITEM 701. GENERAL STRUCTURES

701.1. STRUCTURAL WOOD PRODUCTS

No trees shall be removed unless so noted on the plans or upon the specific approval of the OWNER. Where trees, plants, shrubbery, etc., are adjacent to the line of the work and are not to be removed or are designated on the plans to be removed and replanted, the CONTRACTOR shall protect such trees, plants, shrubbery, and etc.in accordance to the contract documents. If, in the opinion of the OWNER, such trees, plants, shrubbery, etc., would be damaged by machinery, etc., hand excavation may be required. Shrubbery, plants, etc. to be relocated or reused shall be removed with a ball of dirt about their roots and shall be carefully stored and given proper attention.

701.2. STRUCTURAL REMOVAL, EXCAVATION, AND BACKFILL

This item shall govern for the structural removal, excavation, and backfill.

701.2.1. Structural Removal. Removal of existing structures shall consist of the removal and satisfactory disposal of all existing structures and pavements, on the surface or below the ground, which are to be abandoned or removed or that interfere in any way with the new construction, which existing structures are designated for removal on the plans and in these specifications.

Existing structures shall be defined as buildings, foundations, bridges, culverts, headwalls, walls, linings, enclosures, manholes, inlets, cleanouts, valve boxes, pipes, conduits, junction structures, access structures, and other miscellaneous structures or portions thereof of various material composition.

Removal of existing structures shall include the furnishing of all labor, materials, and equipment to accomplish the work to the limits and requirements of the plans and these specifications.

701.2.1.1. Removal of Existing Structures. Materials or parts of the structures not designated for salvage shall become the property of the CONTRACTOR and shall be disposed of by the CONTRACTOR at CONTRACTOR'S own cost and expense at sites approved by the OWNER.

Existing structures which are to be abandoned shall be broken off or removed to a depth of not less than 1 foot below the foundation or subgrade of the new work, unless otherwise provided for in the plans and specifications or approved by the OWNER. Construction of bulkheads and structural plugs shall be done as directed by the OWNER and the cost of such work shall be considered incidental to the contract pay items provided. All operations that endanger new work shall be completed prior to the construction of the new work. Pavement shall be removed only between the lines indicated on the plans. Surface course and sub-base select materials shall be as nearly as practicable removed separately from earth or other excavated materials, stored and utilized as directed by the OWNER. The edges of all openings shall be trimmed smooth and to line, and the face shall be perpendicular to the subgrade.

After removal of structures, all excavations not to be occupied by new work, and all holes created, shall be backfilled in accordance with Item 504. Open Cut-Backfill of these Standard Specifications with approved materials thoroughly compacted in place in lifts of no more than 8 inch thickness (before compaction) and to a density of at least 90 percent of the maximum density determined by ASTM D698 with moisture content within minus 2 to plus 4 of optimum, except that under paved areas, compaction shall be to a density of at least 95 percent.

Damages to adjacent property or structures shall be repaired in a timely fashion, as directed by the OWNER, and shall be repaired by the CONTRACTOR at his sole cost and expense, and to the satisfaction of the OWNER. Any unsightly places created shall be cleaned up and the site of the work left in a neat, clean, and orderly condition.

701.2.1.2. Removal of Existing Pavement. Existing concrete pavements, driveways, curbs, gutters, sidewalks, etc., to be removed shall be broken up and disposed of. Care shall be exercised to leave a neat, uniform edge or joint at the excavation limits or sections removed where only portions are to be removed. Removals shall be to the limits shown on the plans, as directed by the OWNER. Materials designated for salvage shall be salvaged in accordance with Item 701.2.2. Removal and Salvage of Existing Structures. Any additional removal required after the initial removal has been made will be

performed to the limits directed by the OWNER and be paid for in the manner as prescribed under Item 104.2. Change or Modification of Contract of these Standard Specifications.

Removal of asphalt and aggregate pavements shall be considered part of unclassified street excavation work, unless otherwise specifically provided for in the plans and specifications.

701.2.1.3. Measurement and Payment. When the removal work is called for in the plans and specifications, with separate pay items for such work included, measurement for payment shall be as required. Unless otherwise provided in the proposals, no payment shall be made for removal of structures and concrete pavements as such, but such work shall be considered as incidental work and the cost thereof shall be included in the contract pay items provided in the proposal and contract.

When provided for in the proposal and contract, payment for removal of existing structures shall be made at the unit price bid per each or per lump sum, as specified, for removal of existing structures, which price shall be full compensation for all excavation and backfill; for all breaking up and removal of concrete, steel and associated materials; for loading, hauling, unloading, storage, and disposal of materials and structures, including any disposal fees; and for all materials, labor, tools and incidentals necessary to complete the work in accordance with the plans and specifications.

When provided for in the proposal and contract, payment for removal of concrete pavement or modular block paver pavement, when not with concrete base, shall be made at the unit price bid per square yard of concrete or modular block paver pavement actually removed, to the limits shown in the plans and specifications and as directed by the OWNER. Payment for removal of composite block paver and concrete pavements shall be made per square yard of composite pavement actually removed to the limits authorized. Removal of concrete pavement includes removal of variable dimensioned, variable thickness, nonreinforced or reinforced concrete pavement, drives, slabs, integral curbs, and aprons. Pay limits shall be to the back of integral curb removed. Removal of integral curbs shall be considered incidental to removal of the pavement.

When provided for, payment for removal of nonreinforced or reinforced concrete sidewalk shall be made at the unit price bid per square foot of concrete sidewalk removed, to the limits shown in the plans and specifications and as directed by the OWNER. Payment for removal of concrete separate curb or curb with gutter shall be made at the unit price bid per linear foot of concrete curb or curb with gutter actually removed, to the limits shown in the plans and specifications and as directed by the OWNER.

The removal of structures, pavements, sidewalks, curbs, or curbs and gutter in excess of the limits shown in the plans and specifications or in excess of what is directed by the OWNER shall be at the entire cost and expense of the CONTRACTOR and such excess removal areas shall be replaced with adequate structure, pavement and materials as determined and directed by the OWNER, at the CONTRACTOR's entire cost and expense.

701.2.2. Removal and Salvage of Existing Structures. Removal and salvage of existing structures shall consist of the removal and salvage of all existing structures and pavements, on the surface, or below the ground, which are to be removed and salvaged, and which interfere in any way with the new construction and which are designated for removal and salvaging on the plans or in these specifications.

Existing structures shall be defined in Item 701.2.1. Structural Removal, and Item 701.2.2. Removal and Salvage of Existing Structures, shall include the furnishing of all labor, materials, and equipment to accomplish the work to the limits and requirements of the plans and these specifications.

701.2.2.1. Removal and Salvage of Existing Structures. All structures which are to be salvaged will be designated as such, and shall be removed by the CONTRACTOR under the direction of the OWNER, in such a manner as to prevent their being broken or unduly damaged.

Materials or parts of structures which are designated to be salvaged, such as lumber, pipe, brick, modular block pavers, concrete, gravel, castings, etc., shall be removed in a manner approved by the OWNER, and stacked at the site of their removal as directed by the OWNER, and shall remain the property of the City. The salvaged materials will be removed from the site by the City unless otherwise specified in the plans and specifications.

701.2.2.2. Measurement and Payment. If the removal and salvage work is called for in the plans and specifications, with separate bid items for such work included, measurement for payment shall be as required. Otherwise, no payment shall be made for removal and salvage of structures and concrete pavements as such, but such work shall be considered as incidental work and the cost thereof shall be included in the contract pay items provided in the bid proposal and contract.

If specifically provided for in the bid proposal and contract, payment for removal and salvage of existing structures shall be made at the unit price bid per each or per lump sum, as specified, for removal and salvage of existing structures which price shall be full compensation for all excavation and backfill; for all removal of concrete, steel and associated materials; for salvage and storage of materials and structures; and for all materials, labor, tools and incidentals necessary to complete the work in accordance with the plans and specifications.

When provided for in the proposal and contract, payment for removal and salvage of modular block paver pavement shall be made at the unit price bid per square yard of modular block paver pavement actually removed and salvaged, to the limits shown in the plans and specifications and as directed by the OWNER. Payment for removal and salvage of composite block paver and concrete pavements shall be made per square yard of composite pavement actually removed, to the limits authorized.

Payment for removal and salvage of concrete separate curb or curb with gutter performed shall be made at the unit price bid per linear foot of concrete curb or curb with gutter actually removed and salvaged, to the limits shown in the plans and specifications and as directed by the OWNER.

The removal and salvage of structures, pavements, curbs, or curbs and gutter in excess of the limits shown in the plans and specifications, or in excess of what is directed by the OWNER, shall be at the entire cost and expense of the CONTRACTOR and such excess removal areas shall be replaced with adequate structure, pavement and materials as determined and directed by the OWNER, at the CONTRACTOR's entire cost and expense.

701.2.3. Adjustment of Existing Structures. Adjustment of existing structures shall consist of the adjustment of all existing structures and pavements, on the surface, or below the ground, which are to be adjusted or rebuilt, and which interfere in any way with the new construction and which are designated for adjustment on the plans or in these specifications.

Adjustment of existing structures shall include the furnishing of all labor, materials, and equipment to accomplish the work to the limits and requirements of the plans and these specifications.

701.2.3.1. Construction Methods. Existing structures such as manholes, inlets, cleanouts, valve boxes, pipes, etc. which are designated for adjustment in the plans or specifications shall be adjusted, altered or reset to the required elevation and alignment shown in the plans and specifications, as directed by the OWNER. New materials and workmanship necessary shall conform to the requirements of these specifications covering the particular work. Where manholes are to be built up for 1-ft. or less, the walls may be carried up vertically where the walls are to be built up for more than 1-ft., the existing walls shall first be removed down to the bottom of the batter or draw-in section of the walls, or to such an elevation that the inside diameter of the manhole is not less than 3-1/2-ft., the manhole shall then be rebuilt in conformity with the size and shape requirements for new manholes. Salvaged materials in good condition may be used in rebuilding such structures with consent of the OWNER, provided the materials are thoroughly cleaned before their use.

701.2.3.2. Measurement and Payment. If the adjustment of existing structures work is called for in the plans and specifications, with separate bid items for such work included, measurement for payment shall be as required in this item. Otherwise, no payment shall be made for adjustment of structures and concrete pavements as such, but such work shall be considered as incidental work and the cost thereof shall be included in the contract pay items provided in the bid proposal and contract.

If specifically provided for in the bid proposal and contract, payment for adjusting of existing structures shall be made at the unit price bid per each or per lump sum, as specified, for adjusting of existing structures, which price shall be full compensation for all excavation and backfill; for all breaking up and removal of concrete, steel and associated materials; and for all materials, labor, tools and incidentals necessary to complete the work in accordance with the plans and specifications.

701.2.4. Structural, Excavation and Backfill. Structural excavation shall consist of the removal of material for the construction of foundations for bridges, retaining walls, head walls for culverts, or other structures and other excavation designated on the plans or in these specifications as structural excavation, along with the subsequent backfill of these same structures.

Structural backfill shall consist of furnishing material, if necessary, and placing and compacting backfill material around structures to the line designated on the plans, specifications, and/or as directed by OWNER.

Structural excavation and structural backfill shall include the furnishing of all materials and equipment, the construction or installation of all cofferdams in accordance with Item 802.4. Cofferdams and other facilities that may be necessary to perform the work shall be removed, except where they are required or permitted to remain by the plans, specifications, and/or as directed by OWNER.

Structural excavation shall be considered subsidiary to each bid item for which structural excavation is necessary.

For structural excavation and backfill items not covered here, refer to TxDOT Item 400 Excavation and Backfill for Structures.

701.3. STRUCTURAL BOLTING

This item shall govern for the materials to be used and for the method of installation of high-strength bolts used in structural joints.

701.3.1. Materials. Materials shall be as specified and meet the requirements of Item 806.6. Bolts, Nuts and Washers.

701.3.2. Construction Methods.

701.3.2.1. General Requirements. Surfaces of bolted parts in contact with the bolt head and nut shall not have a slope of more than 1:20 with respect to a plane normal to the bolt axis. Bolted parts shall fit solidly together when assembled and shall not be separated by gaskets or any other interposed compressible material. Holes shall be punched, sub-punched and reamed or drilled as required by Item 703.3. Steel Structure Construction. Holes shall be of a nominal diameter not more than $^{1}/_{16}$-in. in excess of the nominal bolt diameter. Field erection and fit-up of joints and splices shall conform to the requirements of Item 703.3. Steel Structure Construction.

When assembled, all joint surfaces, including those adjacent to the washers, shall be free of dirt, rust, loose scale, burrs, and other defects that would prevent solid seating of the parts.

Contact surfaces shall be free of oil, paint, lacquer, or galvanizing.

701.3.2.2. Installation. Bolts shall be installed with a hardened washer under the nut or bolt head, whichever is the element turned in tightening. A hardened washer shall also be used under the head of regular semi-finished hexagon bolts and under finished hexagon nuts, even when these are not the elements turned in tightening. The washer may be omitted under the head of heavy semi-finished hexagon bolts, interference-body bolts, and heavy semi-finished hexagon nuts when these are not the elements turned.

701.3.2.3. Pre-Tightening. Prior to actual tightening of the bolts, the following procedures shall be followed:

(1) A minimum of 20-percent of the holes at a connection point shall be filled with erection pins to “fair-up” all holes.
(2) Install bolts in all remaining holes.
(3) Tighten a minimum of 20-percent of the bolts, following a pattern of progression from the center or most rigid part of the joint toward the free edges, making sure that all plies of the metal in the connection are properly fitted and in contact.
(4) Mark those bolts used for fit-up bolts.
(5) Tighten all the remaining bolts per Item 701.3.2.4.Tightening, then remove the erection pins.
(6) Fill the remaining holes with bolts and loosen all bolts used for fit-up.
(7) Tighten the rest of the bolts per Item 701.3.2.4.Tightening.

701.3.2.4. Tightening. All fasteners shall be tightened to give at least the required minimum bolt tension values shown in Table 701.3.2.4.(a) Bolt Tension on completion of the joint.

Table 701.3.2.4.(a) Bolt Tension

Nominal Bolt Size (in.)	Minimum Tension (kips)	
	ASTM A325 Bolts	ASTM A490 Bolts
½	12	15
5/8	19	24
¾	28	35
7/8	39	49
1	51	64
1-1/8	56	80
1-1/4	71	102
1-3/8	85	121
1-1/2	103	148

Tightening shall be done by one of the following methods:
(1) The Turn-of-the-Nut Method.
(2) The Calibrated-Power Wrench Method.
(3) Gauge Washer Method.

701.3.2.4.1. Turn-of-the-Nut Method. This method indicates the following:

(1) Tighten all bolts used as fit-up bolts to a "snug-tight" condition. (A snug-tight condition is indicated by the wrench when it ceases to spin and just begins to impact, or with a spud wrench by tightening with slight pressure.)
(2) The nut shall be matched-marked with the protruding bolt point before final tightening, thus affording the inspector visual means of noting the actual nut rotation. Such marks shall be made by the operator with a keel, crayon or spot of paint, after the bolts have been brought up to snug-fit.
(3) Tighten the nuts by the amount specified in Table 701.3.2.4.1.(a) Nut Rotation from Snug-Tight Condition. Impact wrenches shall be of adequate capacity and sufficiently supplied with air to perform the required tightening in approximately 10-seconds.

Table 701.3.2.4.1.(a) Nut Rotation from Snug-Tight Condition[1].

Bolt length (underside of head to end of bolt)	Disposition of Outer Face of Bolted Parts		
	Both faces normal to bolt axis	One face normal to bolt axis and other face sloped less than 1:20 (beveled washer not used)	Both faces sloped less than 1:20 from bolt axis (beveled washer not used)
Up to and including 4 bolt diameters	1/3 turn	½ turn	2/3 turn
Over 4 bolt diameters up to and including 8 diameters	½ turn	2/3 turn	5/6 turn
Over 8 bolt diameters up to and including 12 diameters	2/3 turn	5/6 turn	1 turn

1. Nut rotation is relative regardless of the element (nut or bolt) being turned. The tolerance is ± 30º for bolts installed by ½ turn of less and 45º for bolts installed by 2/3 turn or more.

For bolt lengths greater than 12 diameters, determine the required rotation using the installation verification test in a simulated connection of solidly fitted steel.

(4) Fill the remaining holes with bolts and loosen all bolts used for fit-up.
(5) Tighten the rest of the bolts by the required amount.
(6) Tightening crew to mark finished work with identifying symbol.
(7) Inspector mark accepted work.

701.3.2.4.2. Calibrated-Power Wrench Method. When calibrated wrenches are used to provide the bolt tension, their settings shall be such as to induce a bolt tension of 1.05 of the value shown in Table 701.3.2.4.(a) Bolt Tension. The nut shall be matched-marked with the protruding bolt point before final tightening, thus affording the inspector visual means of noting the actual nut rotation. Such marks shall be made by the operator with a keel, crayon or spot of paint, after the bolts have been brought up to snug-fit.

A torque wrench shall be used to check bolts for tightness when the calibrated-power-wrench method is used. The following procedure shall be used to calibrate the torque wrench:

(1) One bolt of the type, size and condition of thread as those to be inspected shall be tightened with the impact wrench, in a device capable of measuring actual bolt tension to the required minimum bolt tension required in Table 701.3.2.4.(a) Bolt Tension.
(2) In this tightened condition, the inspector's torque wrench shall be used to rotate the nut slowly in the tightening direction to move just the nut. The amount required to move the unit shall be used for the inspection torque (use the average of 3 torque values).
(3) When inspecting the bolts installed in the structure, the torque wrench shall be used to tighten the nut; and the torque read just as the nut is set in motion.

Readings higher than the required minimum tension required shall not be cause for rejection. Bolts giving values lower than the required value shall be removed and replaced.

One or two bolts of each size in every connection and a minimum of 10-percent of the bolts in large connections shall be checked. If one or more bolts in a connection are below the required value, all the bolts shall be re-impacted with the calibrated power wrench.

When the calibrated wrench body type of bolt is allowed and used, setting shall be such as to induce a bolt tension slightly in excess of the value shown. The wrenches shall be calibrated by tightening not less than 3 typical bolts of each size from the lot to be installed in a device capable of indicating actual bolt tension.

Power wrenches shall be adjusted to stall out or cut out complete at the selected tension.

When using calibrated wrenches to install bolts, the operator should return to "touch-up" bolts previously tightened, until all bolts are tightened to the prescribed tension. This shall include:

(1) Tightening all bolts not used as fit-up bolts to the tension required by Table 701.3.2.4.(a) Bolt Tension.
(2) Fill the remaining holes with bolts and loosen all bolts used for fit-up.
(3) Tighten the rest of the bolts by the required amount.
(4) Tightening crew to mark finished work with identifying symbol.
(5) Inspector mark accepted work.

701.3.2.4.3. Gauge Washer Method. Use of gauge washers to determine torque shall follow manufacturer instructions.

701.3.3. Inspection. The OWNER shall approve the procedures for calibration of wrenches and installation of bolts. The inspector shall further observe the field installation to determine that these procedures are followed.

Bolts, nuts and washers are normally shipped with a light residual coating of oil. This coating is not detrimental to friction-type connections and need not be removed. Heavy coatings of oil shall be removed. Bolts tightened by the turn-of-the-nut method shall have the outer face of the nut marked along with the end of the bolt with permanent felt markers in order to determine the amount of turn. Close inspection shall be made to insure that the bolts are a tight fit; and that there is no movement of the head in the tightening operation. When the calibrated-wrench method of tightening is used, the CONTRACTOR shall furnish the calibration equipment (Skidmore Wilhelm bolt calibrator or equal).

For the turn-of-the-nut method, the CONTRACTOR shall not be required to furnish equipment or make tests for establishing bolt tension. Such tests, if required, shall be performed by the OWNER. However, the

CONTRACTOR shall not be relieved of the responsibility for re-tightening bolts in case tests indicate the required tension is not being obtained.

701.3.4. Measurement and Payment. No direct compensation shall be made for the installation of bolts. Payment shall be subsidiary to the pertinent item requiring the use of high-strength bolts.

ITEM 702. CONCRETE STRUCTURES

702.1. DESCRIPTION

This specification shall govern for the construction of all types of structures involving the use of structural concrete except where the requirements of this section are not applicable. All concrete structures shall be constructed in accordance with the design requirements and details shown on the plans, with the pertinent provisions of other applicable sections of the specifications, and with the requirements herein provided.

702.2. CONCRETE STRUCTURE MATERIALS

702.2.1. Aggregates for Portland Cement Concrete Structures.

702.2.1.1. General Requirements. Aggregates shall conform to the provisions of Item 303.2.1.1. General Requirements in Item 303.2.1. Aggregates for Portland Cement Concrete Pavement.

702.2.1.2. Fine Aggregates. Fine aggregates shall conform to the provisions of Item 303.2.1.2. Fine Aggregates.

702.2.1.3. Coarse Aggregates. Coarse aggregates shall conform to the provisions of Item 303.2.1.3. Coarse Aggregates.

702.2.1.4. Lightweight Aggregates. Lightweight aggregates shall consist of expanded clay or shale having strong, durable particles; and conforming to the requirements of ASTM C330 Lightweight Aggregates for Structural Concrete.

702.2.1.4.1. Foreign Material and Deleterious Substances. Deleterious substances, elements, or components are those that are damaging, harmful, undesirable, or adulterating to the integrity or purity of the specified base material. The maximum permissible percentage, by weight, of deleterious substances shall not exceed the amounts in Table 702.2.1.4.1.(a) Deleterious Substances in Lightweight Aggregates.

Lightweight aggregates that, upon being subjected to the test for organic impurities, produce a color darker than the standard shall be rejected, unless it can be demonstrated that the discoloration is due to small quantities of materials not harmful to the concrete.

If, after a test for staining materials (ASTM C641 Staining Materials in Lightweight Concrete Aggregates), the aggregates are classified as “heavy stain” or darker, a test following the chemical procedure shall be performed. If 1.5-mg or more of ferric oxide ($Fe_2 0_3$) per 200-g sample is found, the aggregate shall be rejected.

Table 702.2.1.4.1.(a) Deleterious Substances in Lightweight Aggregates

Substance	Maximum % by Weight
Loss on ignition	5%
Clay lumps	2%

702.2.1.4.2. Gradation. The lightweight aggregate shall be well graded in size from coarse to fine. When tested by standard laboratory methods lightweight aggregate shall meet the requirements in Table 702.2.1.4.2.(a) Grading Requirements for Lightweight Aggregates for percentage passing each sieve by weight.

Table 702.2.1.4.2.(a) Grading Requirements for Lightweight Aggregates

Sieve	Percent Passing
3/4 in. sieve (19.0 mm)	90 to 100%
3/8 in. sieve (9.5 mm)	20 to 55%
Passing No. 4 sieve (4.75 mm)	0 to 10%
Passing No. 8 sieve (2.36 mm)	0 to 5%

702.2.1.4.3. Natural Fine Aggregate. At the option of the CONTRACTOR, natural fine aggregate may be substituted for fine lightweight aggregate, provided such substitution does not result in producing concrete that has a weight in excess of the permissible maximum specified herein. Natural fine aggregate shall meet the grading requirements of Table 303.2.1.2.2.(a) Grading Requirements for Fine Aggregates. Natural fine aggregate shall have a percent of wear not more than 40 when tested according to ASTM C131 Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine.

702.2.1.4.4. Rejection. Lightweight aggregates which fail to meet the requirements for these specifications may be rejected by the OWNER. Such rejection shall incur no cost to the OWNER.

If lightweight aggregate with properties not meeting these specifications are delivered to the project, the source of the material may be rejected as a further supply source by the OWNER. Such rejection shall incur no cost to the OWNER.

702.2.1.5. Pit-Run and Re-Mix Aggregate. Pit-run aggregate is the natural gravel and sand obtained from pits without the addition of other fine or coarse aggregates and shall consist of hard, durable, uncoated pebbles or stone particles mixed with sand. Pit-run aggregate shall not be used for high strength concrete of 3000-psi and above. Pit-run aggregate may be used only for concrete cushion, cradle and protection for pipe.

Re-mix aggregate is native rock and sand that has been washed and screened and meets the specified gradation. Re-mix aggregate shall not be used for high-strength concrete of 3000-psi and above. Re-mix aggregate may be used only as a substitute for pit-run aggregate or when specified.

702.2.1.5.1. Foreign Material and Deleterious Substances. Pit-run and re-mix aggregate shall be free from lumps of clay and from injurious amounts of dust, shale, soft or flaky particles, salt and alkali.

702.2.1.5.2. Gradation. Pit-run and re-mix aggregate shall be well graded from coarse to fine when tested by standard laboratory methods and shall meet the minimum requirements for percentages by weight in Table 702.2.1.5.2.(a) Grading Requirements for Pit-Run and Re-Mix Aggregate.

Table 702.2.1.5.2.(a) Grading Requirements for Pit-Run and Re-Mix Aggregate

Sieve	Percent Retained by Weight
1/4-in. (6 mm) sieve	55 to 60%

702.2.1.5.3. Rejection. Pit-run and re-mix aggregate may be rejected for failure to meet any of the requirements of this specification. Such rejection shall incur no cost to the OWNER.

Aggregate sources from which materials with properties not meeting these specifications are delivered may be rejected as a further supply source to the project by the OWNER. Such rejection shall incur no cost to the OWNER.

702.2.1.6. Alkali-Silica Reactions (ASR) and Delayed Ettringite Formation (DEF) Mitigation. Refer to TxDOT Item 421 Hydraulic Cement Concrete.

702.2.2. Portland Cement. Portland Cement shall conform with the requirements of Item 303.2.2. Portland Cement.

702.2.3. Concrete Additives and Modifiers. Concrete additives and modifiers shall conform to the applicable requirements of Item 303.2.3. Chemical Admixtures, Item 303.2.4. Mineral Admixtures, Item 303.2.5. Mineral Filler, and/or Item 303.2.6. Fibrous Reinforcement.

702.2.4. Water. Water shall conform to the requirements of Item 303.2.7. Water.

702.2.5. Reinforcement. Reinforcement, if any, shall conform to the requirements of Item 303.2.9. Steel Reinforcement, except that axle steel shall not be permitted on structures and the use of rail steel or axle steel shall not be permitted for use in railroad underpass structures. At the OWNER'S option the use of welded wire fabric in accordance with Item 303.2.10. Steel Wire Reinforcement may be used.

702.2.5.1. Epoxy Coated Bars. For use of epoxy coated bars, refer to TxDOT Standard Specifications for Construction and Maintenance of Highways, Streets, and Bridges.

702.2.6. Joint Filler and Joint Sealer. Joint filler shall conform to the requirements of Item 303.2.12. Joint Filler. Joint sealer shall conform to the requirements of Item 303.2.14. Joint Sealant.

702.2.7. Curing Materials. Curing materials shall conform to the requirements of Item 303.2.13. Curing Materials.

702.2.8. Elastomeric Materials. Elastomeric materials shall conform to the requirements of Item 303.2.15. Elastomeric Materials.

702.3. MIX DESIGN AND MIXING CONCRETE FOR STRUCTURES

702.3.1. Description. This section shall govern for the concrete used in bridges, box culverts, and such other miscellaneous structures and incidentals necessary to complete the work.

702.3.2. Equipment. All machinery and equipment necessary for the prosecution of the work specified herein shall be on the project and shall be approved by the OWNER as to condition before the CONTRACTOR shall be permitted to begin operations on which the machinery or equipment is to be used. All machinery and equipment shall be maintained in good condition to insure the completion of the work without excessive delays for repairs and replacements.

702.3.3. Concrete Mix Design and Control. The OWNER shall furnish plant control of the concrete by securing the services of an independent local testing laboratory. Within a period of not less than 10-days prior to the start of concreting operations, the CONTRACTOR shall submit to the OWNER a design of the concrete mix it proposes to use, together with samples of all materials to be incorporated into the mix and a full description of the source of supply of each material component. The design of the concrete mix shall produce a concrete complying with the requirements of concrete classes in Table 702.3.4.2.(a) Standard Classes of Structural Concrete or Table 702.3.4.3.(a) Performance Classes of Structural Concrete and slump in Table 702.3.4.4.(a) Structural Concrete Slump Requirements.

The dry loose volume of coarse aggregate shall not be more than 0.82 cubic-feet-per-cubic-foot of concrete, except in cases where the voids in the coarse aggregate as determined by standard test methods exceed 48-percent of the total dry loose volume. Where voids exceed 48-percent, the dry loose volume of coarse aggregate shall not exceed 0.85-cubic-feet-per-cubic-foot of concrete.

If the strength required for the class of concrete being produced is not secured with the cement specified in Table 702.3.4.2.(a) Standard Classes of Structural Concrete or Table 702.3.4.3.(a) Performance Classes of Structural Concrete, the CONTRACTOR may use, or the OWNER may require, an approved cement dispersing agent, or the CONTRACTOR shall furnish additional aggregates or aggregates with different characteristics which shall produce the required results. Additional cement may be required or permitted as a temporary measure until aggregates are changed and designs checked with the different aggregates or cement dispersing agent.

All material samples submitted to the OWNER shall be sufficiently large to permit laboratory batching for the construction of test beams to check the adequacy of the design. When the design mix has been approved by the OWNER, there shall be no change or deviation from the proportions thereof or sources of supply except as hereinafter provided. No concrete may be placed on the job site until the mix design has been approved by the OWNER in writing to the CONTRACTOR.

702.3.4. Quality of Concrete.

702.3.4.1. Consistency. In general, the consistency of concrete mixtures shall be such that:

(1) the mortar shall cling to the coarse aggregate,
(2) the aggregate shall not segregate in concrete when it is transported to the place of deposit,
(3) the concrete, when dropped directly from the discharge chute of the mixer, shall flatten out at the center of the pile, but the edges of the pile shall stand and not flow,
(4) the concrete and mortar shall show no free water when removed from the mixer,
(5) the concrete shall slide and not flow into place when transported in metal chutes at an angle of 30° with the horizontal, and
(6) the surface of the finished concrete shall be free from a surface film or laitance.

(7) The concrete shall be uniform and workable.

The cement content, maximum allowable water cement ratio, the average and maximum slump and the strength requirements of the various classes of concrete shall conform to the requirements of the tables below, and as required herein.

The consistency of the concrete as placed should allow the completion of all finishing operations without the addition of water to the surface. When field conditions are such that additional moisture is needed for the final concrete surface finishing operation, the required water shall be applied to the surface by misting only and shall be held to a minimum amount. The concrete shall be workable, cohesive, possess satisfactory finishing qualities and be of the stiffest consistency that can be placed and vibrated into a homogeneous mass. Excessive bleeding shall be avoided.

If the strength or consistency required for the class of concrete being produced is not secured with the minimum cement specified or without exceeding the maximum water/ cement ratio, the CONTRACTOR may use, or the OWNER may require, an approved cement dispersing agent (water reducer); or the CONTRACTOR shall furnish additional aggregates, or aggregates with different characteristics, or the CONTRACTOR may use additional cement in order to produce the required results. The additional cement may be permitted as a temporary measure, until aggregates are changed and designs checked with the different aggregates or cement-dispersing agent.

The CONTRACTOR is solely responsible for the quality of the concrete produced. The OWNER reserves the right to independently verify the quality of the concrete through inspection of the batch plant, testing of the various materials used in the concrete, and by casting and testing concrete cylinders or beams on the concrete actually incorporated in the structure.

Unless otherwise shown on the plans or detailed specifications, the Standard Classes of Concrete table shall be used.

702.3.4.2. Standard Classes. Standard classes of structural concrete shall meet the requirements in Table 702.3.4.2.(a) Standard Classes of Structural Concrete.

Table 702.3.4.2.(a) Standard Classes of Structural Concrete.

Class of Concrete[1]	Minimum Cementitious Lb./CY	Minimum Cementitious Sacks/CY	28 Day Min. Compressive Strength[2] psi	28 Day Min. Beam Strength[2,3] psi	Maximum Water/ Cementitious Ratio	Coarse Aggregate Maximum Size[4]
A	470	5.0	3000	500	0.58	1½"
B	376	4.0	2000	330	0.71	1½"
C	564	6.0	3600	600	0.53	1½"
D	282	3.0	1500	250	0.97	1½"
E	564	6.0	3000	500	0.62	1½"
F	611	6.5	4200	700	0.49	1½"
S	564	6.0	3600	600	0.44	1½"
H[5]	611	6.5	As Specified On Plans	N/A	0.49	1"
M	As directed by the OWNER or as shown on the plans					

1. All exposed concrete shall have entrained – air (See 303.2.3. Chemical Admixtures).
2. Minimum Strength Required by OWNER [Compressive or Flexural]
3. ASTM C78 (Third-Point); Reduce by 10% when Type II Cement is Used
4. Smaller Nominal Maximum Size Aggregate May be Used if Strength requirement is Satisfied
5. Prestressed Concrete

702.3.4.3. Performance Classes. Performance Classes of structural concrete shall meet the requirements in Table 702.3.4.3.(a) Performance Classes of Structural Concrete.

Table 702.3.4.3.(a) Performance Classes of Structural Concrete

Class of Concrete[1]	Minimum Cementitious Lb./CY	Minimum Cementitious Sacks/CY	28-Day Compressive Strength[2] psi	28-Day Flexural Strength[3,4] psi	Maximum Water/ Cementitious Ratio[4]	Coarse Aggregate Maximum Size[5]
PA	423	4.5	3000	425	0.58	1½"
PB	350	4.0	2000	N/A	0.71	1½"
PC	517	5.5	3600	510	0.53	1½"
PD	250	3.0	1500	N/A	0.97	1½"
PE	470	5.0	3000	425	0.62	1½"
PF	564	6.0	4200	595	0.49	1½"
PS	517	5.5	3600	510	0.44	1½"
PH[6]	611	6.5	As specified on plans	N/A	0.49	1"
PM	As directed by the OWNER or as shown on the plans					

1. All exposed concrete shall have entrained – air (See 303.2.3. Chemical Admixtures).
2. Calculated Average Required Compressive Strength Considering ACI 318 - Sec. 5.3.2.1 shall be strength shown times 1.15.
3. ASTM C78 (Third-Point); Reduce by 10% when Type II Cement is Used
4. Consistent with ACI 211.1 Table 6.3.4(a) Relationship between water-cementitious materials ratio and compressive strength of concrete
5. Smaller maximum size aggregate may be used if strength requirement is satisfied
6. Prestressed Concrete

702.3.4.4. Slump. Slump requirements for structural concrete shall be as specified in Table 702.3.4.4.(a) Structural Concrete Slump Requirements. No concrete shall be permitted with slump in excess of the maximums shown. Any concrete mix failing to meet the above consistency requirements, although meeting the slump requirements, shall be considered unsatisfactory, and the mix shall be rejected and changed to correct such unsatisfactory conditions at no cost to the OWNER.

Table 702.3.4.4.(a) Structural Concrete Slump Requirements.

Concrete Use	Avg. Slump (in.)	Max. Slump (in.)
Cased Drilled Shafts and Thin-walled Sections (9 in. or less)	6	7
Slabs, Caps, Wall Sections Over 9 in., etc.	3	4
Columns, Piers	4	5
Underwater or Seal Concrete	7	8
Other Miscellaneous Concrete	As specified by OWNER	

702.3.4.5. Tests. During the progress of the work, the CONTRACTOR shall cast test cylinders in accordance with ASTM C31 Standard Practice for Making and Curing Concrete Test Specimens in the Field to maintain a check on the compressive strengths of the concrete being placed. In accordance with ASTM C31 and ASTM C172 Standard Practice for Sampling Freshly Mixed Concrete, four test cylinders shall be taken from a representative portion of the concrete being placed for every 40-cubic-yards of concrete placed. After the cylinders have been cast, they shall remain on the job site and then transported, moist cured, and tested by the OWNER in accordance with ASTM C31 and C39 Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens.

The CONTRACTOR shall provide and maintain curing facilities for the purpose of curing concrete test specimens on site in accordance with ASTM C31. The CONTRACTOR shall be responsible for the proper storage, maintenance, and any required curing of concrete test samples made by the OWNER, and any costs thereof.

In each set, two of the cylinders shall be tested at 7-days, two cylinders shall be tested at 28-days. If the 28-day test results indicate deficient strength, the CONTRACTOR may, at its option and expense, core the concrete in question and have the cores tested by an approved laboratory, in accordance with ASTM C42 Standard Test Method for Obtaining and Testing Drilled Cores and Sawed Beams of Concrete and ACI 318 protocol, to override the results of the cylinder tests.

Cylinders and/or cores must meet the specified strength in accordance with ACI 318 protocol. The testing does not in any way change the penalties imposed on the CONTRACTOR for deficient strength outlined elsewhere in these specifications.

At the OWNER'S direction, beam test may be required and utilized for acceptance of the final product.

702.3.5. Mixing.

702.3.5.1. General. Concrete shall be mixed in a machine, of approved design and capacity, which receives a complete charge of proportioned materials and thoroughly and evenly mixes the charge as a whole before any part is withdrawn from the machine. The mixing shall be continued until each particle of stone or gravel is completely covered with mortar and the batch is of uniform color and consistency. The manufacturer's recommended mixing time shall be adhered to or mixing shall continue until a uniform concrete mixture is obtained. The mixer shall be equipped with an attachment for satisfactorily locking the discharging device so as to prevent the emptying of the mixer until all the materials have been mixed together for the minimum time required. The entire contents of the drum shall be discharged before any materials are placed therein for the succeeding batch.

702.3.5.2. Transit Mix Concrete. Transit mix concrete shall meet the following conditions:

(1) all requirements otherwise specified for mixing on the job shall apply,
(2) sufficient transit mix equipment shall be assigned exclusively to the project as required for continuous operation,
(3) satisfactory evidence shall be furnished so that the delivery of concrete shall be continuous at regular and uniform intervals, without stoppages or interruption,
(4) the supplier of transit mix concrete shall furnish a written statement addressed to the OWNER, stating that the concrete shall be produced in accordance with these specifications and subject to the approval of the OWNER, and
(5) concrete shall not be placed on the job after a period of 1½-hours after the cement has been placed in the mixer.

702.3.5.3. Continuous Volumetric Mix Concrete. For all miscellaneous concrete placements, a mobile, continuous, volumetric mixer of the rotating paddle type may be used when approved or specified by the OWNER.

These mixers shall be designed to receive all the concrete ingredients, including admixtures, required by the mix design in a continuous uniform rate and mix them to the required consistency before discharging. The mixers shall have adequate water supply and metering devices. Calibration of these mixers will be required.

The mixing time shall be in accordance with the recommendations of the manufacturer of the mixer unless otherwise revised by the Engineer.

For continuous volumetric mixers, the materials delivered during a revolution of the driving mechanism, or in a selected time interval, will be considered a batch, and the proportion of each ingredient will be calculated in the same manner as for a batch type plant.

702.4. MIX DESIGN AND MIXING LIGHTWEIGHT CONCRETE FOR STRUCTURES

702.4.1. Description. This item shall govern the equipment used; the storing, measuring and handling of materials; and for the mixing, placing, finishing and curing of lightweight concrete for bridges and other structures. The concrete shall be composed of Portland cement, natural sand fine aggregate, lightweight coarse aggregate, a cement dispersing agent, an air-entraining admixture and water, proportioned and mixed as hereinafter provided.

702.4.2. Quality of Concrete.

702.4.2.1. Consistency. Concrete shall be of such consistency so as to insure the required workability and result in compact masses having dense, uniform surfaces. The proportions of the ingredients shall be varied only with the approval of the OWNER. In general, the consistency of lightweight concrete should be similar to that of natural aggregate concrete. Batches which are harsh and unworkable shall be redesigned at the CONTRACTOR'S expense.

702.4.2.2. Classifaction and Proportions. Lightweight concrete shall be proportioned by weight in such manner as to secure a uniform and workable mix which shall produce cured concrete of the weight and strength specified herein. Prior to mixing any concrete which shall be used in the structure, the CONTRACTOR shall prepare trial batches, proportioned and tested in accordance with TxDOT Construction Bulletin C-11. Additional sand may be required to improve workability of the mix.

The cement content, maximum air content and slump of the various classes of concrete, shall conform to Table 702.4.2.(a) Classes of Lightweight Concrete. If the strength required for the class of concrete being produced is not secure with the minimum cement content specified, additional cement shall be used or other aggregates provided at the CONTRACTOR'S expense.

Table 702.4.2.(a) Classes of Lightweight Concrete

Class	Min. - Max. Bags Cement per C.Y.	Min. Comp. Strength 28-Day (psi)	Max. Slump (in.)	Air-Dried Weight Max. (lb./CF)[1]	Total Air Content, %	Use
X	5.5 - 7.5	3000	See note [2]	110	6 – 9	General Structural
Y	5.5. - 7.0	5000	3	115	6 – 9	Prestressed Concrete
Z	5.5 - 8.0	As specified on plans	3	118	6 – 9	Prestressed Concrete

1. Air-dried weight shall be measured after 7-days moist curing at 100-percent relative humidity at 73°±2°F and stored for 21-days at 50±2-percent relative humidity.
2. Class X concrete shall be placed so that the average slump shall be maintained at approximately 3-in. No concrete shall be permitted with a slump in excess of 4-in.

702.4.2.3. Tests. During the progress of the work, the OWNER shall cast and test cylinders to maintain a check on the compressive strength of the concrete being placed.

For prestressed lightweight concrete, two tests (6-test cylinders) for each pertinent strength test required by Table 702.4.2.(a) Classes of Lightweight Concrete shall be required for each separate stressing line of beams, spans, piling, etc., as the case may be. Testing and curing of cylinders shall be in accordance with Item 702.3.4.5. Tests. Job control cylinders may be tested on a hand operated compression machine. Equipment shall be furnished by the CONTRACTOR if required.

Air content shall be checked by use of a pressure type air meter in accordance with ASTM C231 Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method.

Test for wet weight shall be made in accordance with ASTM C138 Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete.

The relationship between the air-dried weight of concrete and the wet weight of concrete shall be established by the OWNER, based upon trial batches and checks made during progress of the work.

For each change in batch design weight and for each 25-cubic-yards of concrete placed in the structure, two tests for weight shall be made. At any time that the average of these tests indicates a wet weight in excess of that which has been determined to produce air-dried concrete of the specified weight, the batch shall be adjusted to reduce the wet weight of concrete by the amount required.

702.4.3. Mixing. The following shall govern the mixing of lightweight concrete:

(1) The cement dispersing agent and at least two-thirds of the total mixing water shall be introduced in the mixer and mixed for 15-seconds,

(2) the fine and coarse aggregate shall be added and mixed for 45-second, and
(3) the cement and final water shall be added and mixing completed. The minimum mixing time shall be determined by the OWNER for the concrete batch and the equipment used, but in no case shall the total mixing time be less than 3-minutes. Minimum mixing for concrete mixed in trucks shall be 100 revolutions of the drum.

The drum on truck mixers shall be operated at high speed while charging it with aggregate. Cement shall be introduced into the mixing drum while it is rotating at slow speed. Immediately prior to discharge of the concrete, the drum shall be rotated at high speed for 30-seconds.

702.5. CONSTRUCTING CONCRETE STRUCTURES

702.5.1. Submittals. Before starting work, the CONTRACTOR shall inform the OWNER fully of the methods of construction it proposes to follow and the amount and character of equipment it proposes to use, the adequacy of which shall be subject to the approval of the OWNER. Plans for forms and false-work for concrete piers and concrete superstructure spans over 20-ft. in length and for all widening details shall be submitted to the OWNER for review and approval. Similar plans shall be submitted for other units of the structure if required by the OWNER. The plans shall be prepared on standard 24-in. by 36-in. sheets or on mutually agreeable standard sheet sizes, such as, 11-in. by 17-in. sheets. Plans shall show all essential details of the proposed forms, false-work and bracing so that a structural analysis may be made. Six sets (or as directed by OWNER) of such plans, sealed by a Professional Engineer registered in the state of Texas shall be required.

Concurrence on the part of the OWNER in any proposed construction methods, approval of equipment or approval of form and false-work plans does not relieve the CONTRACTOR of the responsibility for the safety or correctness of its methods and adequacy of its equipment or from carrying out the work in full accordance with the contract.

702.5.2. Time Sequence. Unless otherwise provided, the following requirements shall govern for the time sequence in which construction operations may be carried on:

(1) No superstructure members, forms, false-work or erection equipment shall be placed on the substructure before the substructure concrete has attained 75-percent design strength, as indicated by field-cured test specimens as approved by the OWNER.
(2) The use of completed portions of a structure for storage of materials shall not be permitted until all curing requirements for the particular part of the structure have been met.
(3) Forms for wall or columns shall not be erected on concrete footings until the concrete in the footing has cured at least 2-days. Concrete may be placed in the wall or column as soon as the forms and reinforcing steel placement are approved.
(4) The support tie beam and/or cap forms by false-work placed on previously placed tie beams is permissible, provided such supporting beams have attained 75-percent design strength as indicated by field-cured test specimens as approved by the OWNER, curing requirements are completed, and the beams are properly supported to eliminate stresses not provided for in the design.

702.5.3. Drains. Weep hole drains and roadway drains shall be installed and constructed as shown on the plans in the designated locations. When the concrete is not formed at the weep hole location, a sheet of building paper shall be placed over the gravel to prevent the entrance of concrete into the pocket during operations.

702.5.4. Joints.

702.5.4.1. Expansion Joints. Expansion joints and devices to provide for expansion and contraction shall be constructed where indicated herein or on the plans.

The bearing area under the expansion ends of concrete slabs, prestressed concrete beams, girders and slab and girder spans shall be given a steel trowel finish. These areas shall be finished to the exact grades required. The material used in separate expansion surfaces shall be that shown on the plans and shall be placed carefully so that concrete or mortar cannot be subsequently worked around or under the material.

Immediately after the removal of forms and again when necessary after surface finishing, all projecting concrete shall be removed along exposed edges in order to secure full effectiveness of the expansion joints.

Refer to Item 303.5.4.2. Expansion Joints for more information.

702.5.4.2. Construction Joints. The joint formed by placing plastic concrete in direct contract with concrete that has attained its initial set shall be deemed a construction joint. When concrete is to be placed monolithically, the term monolithic shall be interpreted to mean that the manner and sequence of concrete placing shall be such that construction joints shall not be created.

Construction joints shall be of the type and at the locations shown on the plans. Additional joints shall not be permitted without written authorization from the OWNER. Any additional construction joints shall have details equivalent to those shown on the plans for joints in similar locations.

Unless otherwise provided, construction joints shall be square and normal to the forms. Bulkheads shall be provided in the forms for all joints except horizontal joints.

Construction joints requiring the use of joint sealing material shall be as detailed on the plans. The material shall be specified on the plans without reference to joint type.

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

Before joining plastic concrete to concrete that has already set, the surface of the concrete in place shall be free from all loose material, laitance, dirt or foreign matter; shall be washed, scrubbed clean and drenched thoroughly with water until saturated; and shall be kept moist until the plastic concrete has been placed. Immediately prior to the placing of additional concrete, all forms shall be drawn tight against the existing concrete and the existing joint surface shall be flushed with a coating of grout mixed in the proportions of one part of cement to two parts of sand.

Refer to Item 303.5.4.4. Construction Joints for more information.

702.5.5. False-work. All false-work shall be designed and constructed to safely carry the maximum anticipated loads and to provide the necessary rigidity. Details of false-work construction shall be subject to review and approval by the OWNER in accordance with the provisions of Item 702.5.6. Forms. When the false-work is no longer required, it shall be removed. False-work piling shall be pulled or cut off a minimum of 6-in. below finished ground level. False-work and piling in a stream or lake shall be removed completely to a point specified by the OWNER to prevent any obstruction to the waterway. Removal shall also be subject to the provisions of Item 702.5.11. Removal of Forms and False-Work.

702.5.6. Forms.

702.5.6.1. General. Forming plans shall be submitted for approval. Forms shall be designed for the pressure exerted by a liquid weighing 150-lb-per-cubic-foot. The rate of placing the concrete shall be taken into consideration in determining the depth of the equivalent liquid. An additional live load of 50-lb-per-square-foot shall be allowed on horizontal surfaces. The maximum unit stresses shall not exceed 125-percent of the allowable stresses used by TxDOT for the design of structures.

Forms shall be of suitable material and of a type, size, shape, quality and strength to insure construction as designed. Wood products for use in forming concrete shall conform to ACI Standard SP-4 Formwork for Concrete. The forms shall be true to line and grade, mortar tight and sufficiently rigid to resist deflection during placing of the concrete. The responsibilities for adequacy shall rest with the CONTRACTOR. All dirt, chips, sawdust, nails and other foreign matter shall be completely removed from forms before any concrete is deposited therein. The surfaces of forms shall be smooth and free from irregularities, dents, sags and holes that would deface the finished surfaces. Forms previously used shall be thoroughly cleaned of all dirt, mortar and foreign matter before being reused. Before concrete is placed in forms, all inside surfaces of the forms shall be thoroughly treated with an approved releasing agent which shall leave no objectionable film on the surface of the forms that can be absorbed by the concrete. Care shall be exercised that no releasing agent is deposited on previously placed concrete, reinforcement or embedded metal items.

Forms for all surfaces that shall not be completely enclosed or hidden below the permanent surface of the ground shall be made of surfaced lumber or material which shall provide a surface at least equal to surfaced lumber or plywood. Any lumber or material which becomes badly checked or warped prior to placing concrete shall not be used.

Forms for all exposed surfaces of bridges, viaducts, over-crossings and similar structures shall be constructed of plywood or an approved equal. Plywood for forms shall be exterior type, of the grade "Concrete-Form Exterior," conforming to the specifications of the U.S. Department of Commerce, "National Bureau of Standards, Commercial Standards," latest edition. Plywood shall be furnished and placed in 48-in. widths and in uniform lengths of not less than 96-in., except where the dimension of the member formed is less than the specified panel dimension. Plywood shall be placed with the grain of the outer plys in the direction of the span. Where plywood is attached directly to the studs or joists, the panels shall not be less than ⅝-in. thick, and the studs or joists shall be spaced not more than 12-in. center to center. Plywood form panels otherwise conforming to the requirements specified herein may be used with a continuous backing of ¾-in. sheeting. All form panels shall be placed in a neat, symmetrical pattern with the horizontal joints level and continuous. All joints shall be filled with an approved quick-setting compound and finished flush with the interior of the form.

Forms for round columns exposed to view shall be of steel, except that other materials shall be allowed with written permission of the OWNER.

Removal shall be accomplished according to the provisions of Item 702.5.11. Removal of Forms and False-Work.

702.5.6.2. Molding. Molding specified for chamfer strips and other uses shall be made of redwood, cypress or white pine materials of such grade that it shall not split when nailed and which can be maintained to a true line without warping. The molding shall be mill-cut and dressed on all surfaces.

702.5.6.3. Form Ties and Spreaders. Metal form ties of an approved type or an approved substitute shall be used to hold forms in place. Pipe spreaders shall not be permitted. Metal and wooden spreaders which are separate from the forms shall be entirely removed as the concrete is being placed. All metal ties, wire or other appliances used inside the forms to hold them in correct alignment shall be removed to a depth of at least ½-in. from the surface of the concrete. Burning off of rods, bolts or ties shall not be permitted. The cavities produced shall be carefully cleaned and completely filled with retempered sand-cement mortar mixed in proportions of 1-to-3 and the concrete shall be left smooth and even.

702.5.6.4. Form Supports for Overhanging Slabs. Form supports which transmit a horizontal force to a steel girder or beam or to a prestressed concrete beam shall be permitted but shall not be used unless a structural analysis has been made of the effect on the girder or beam and approval is granted by the OWNER.

Holes in steel members for support of overhanging brackets may be punched or drilled full size or may be torch cut to ¼-in. under size and reamed full size as provided for in Item 703. Steel Structures. In no case shall the holes be burned full size. All such holes must be approved by the OWNER in writing prior to punching, drilling or burning. Holes shall be left open unless specified on the plans to be filled with a button head bolt. In no case shall the holes be filled by welding.

702.5.7. Placing Reinforcement. Reinforcement in concrete structures shall be placed carefully and accurately and rigidly supported as provided in Item 303.5.3. Placing Reinforcing Steel, Tie, and Dowel Bars and as shown on the plans.

702.5.8. Placing Concrete.

702.5.8.1. General. The CONTRACTOR shall give the OWNER sufficient advance notice before starting to place concrete in any unit of the structure to permit the inspection of forms, the reinforcing steel placement and preparation for casting. No concrete shall be placed in any unit prior to the completion of the formwork, the placement of the reinforcement and approval by the OWNER. Concrete mixing, placing and finishing shall be done in daylight hours, unless adequate provisions are made to light the entire site of all operations.

The minimum temperature of all concrete at the time of placement shall be not less than 50°F. The maximum temperature of Class C, F, H, X, Y and Z or Class PC, PF, PH (as specified by the OWNER) cast-in-place concrete used in bridge superstructures shall not be more than 85°F at the time of placement. Concrete diaphragms, parapets, concrete portions of railings, curbs and sidewalks, unless monolithically placed with the slab, may not be subject to the preceding control if approved by the OWNER in writing. Other portions of structures, when so noted on the plans, shall require the temperature control specified thereon.

A retarding admixture shall be used when the continuous placing method is used in the deck of continuous units. The initial set of the concrete shall be retarded sufficiently to insure that the concrete remains plastic in not less than 3 spans immediately preceding the one being placed. For simple spans, retardation shall be required only if necessary to complete finishing operations or as required by Item 303. Portland Cement Concrete Pavement. The retarding admixture shall be in accordance with the requirements of Item 702.2.3. Concrete Additives and Modifiers.

The consistency of the concrete as placed should allow the completion of all finishing operations without the addition of water to the surface. When conditions are such that additional moisture is needed for finishing, the required water shall be applied to the surface by misting only and shall be held to a minimum amount.

The maximum time interval between the addition of cement or mixing water to the batch and the placing of concrete in the forms shall not exceed amounts shown in Table 702.5.8.1.(a) Interval Between Mixing and Placing Concrete.

Table 702.5.8.1.(a) Interval Between Mixing and Placing Concrete.

Type	Air or Concrete Temperature		Maximum Time[1]
	°F	°C	
Nonagitated Concrete			
	80°F or above	26.6°C or above	15 minutes
	38°F[2] or 79°F	3.3° to 26.1°C	30 minutes
Agitated Concrete			
	90°F or above	32.2°C or above	45 minutes
	75°F to 89°F	23.9° to 31.6°C	60 minutes
	38°F[2] to 74°F	3.3° to 23.3°C	90 minutes

1. The use of an approved cement dispersing agent in the concrete shall permit the extension of each of the temperature-time maximums by 30-minutes, except that for non-agitated concrete, the maximum time shall not exceed 30-minutes.
2. Minimum temperature is 38°F and rising.
3. The maximum temperature shall not be more than 85°F at the time of placement.

The sequence of placing concrete shall be as provided on the plans or in the specifications. The placing shall be so regulated that the pressures caused by the plastic concrete shall not exceed the loads used in the design of forms.

The method of handling, placing and consolidation of concrete shall minimize segregation or the displacement of the reinforcement and shall produce a compact mass of uniform texture. Concrete shall not have a free fall of more than 3-ft. except in the case of thin walls such as culvert walls. The spattering of forms or reinforcement bars shall be prevented if the concrete so spattered shall dry or harden before being incorporated into the mass.

Laitance or foreign matter of any kind shall not be permitted to accumulate inside the forms, and openings in forms necessary for removal of same shall be provided.

Any hardened concrete spatter ahead of the plastic concrete shall promptly be removed from the work.

Each part of the forms shall be filled by depositing concrete as near its final position as possible. The coarse aggregate shall be worked back from the face and concrete forced under and around the

reinforcement bars without displacing them. Depositing large quantities at one point in the forms and running or working it along the forms shall not be allowed.

After the concrete has taken initial set, the forms shall not be jarred or any strain placed on projecting reinforcement.

Chutes, troughs, conveyors or pipes used in placing concrete shall be arranged and used so that the ingredients of the concrete shall not be separated. When steep slopes are necessary, the chutes shall be equipped with baffle boards or made in short lengths that reverse the direction of movement, or the ends of such chutes shall terminate in vertical downspouts. Open troughs and chutes shall extend, if necessary, down inside the forms or through holes left in the forms. All chutes, troughs, conveyors and pipes shall be kept clean and free from coatings of hardened concrete by a thorough flushing with water before and after each placement. Water used for flushing shall be discharged clear of the concrete.

Concrete shall be deposited in the forms in layers of suitable depth but not more than 36-in. in thickness, unless otherwise directed by OWNER.

Holes for anchor bolts in piers, abutments, bents or pedestals may be drilled or may be formed by the insertion of oiled wooden plugs or metal sleeves in the plastic concrete. The plugs or sleeves shall be withdrawn after the concrete has set. Formed holes shall be of such diameter to permit horizontal adjustments of the bolts. The bolts shall be set carefully in mortar in lieu of the above methods of placing. Anchor bolts may be set to exact location in concrete when it is placed.

The placing of concrete for deck slabs shall be done from a mixing plant located off the structure. Carting or wheeling concrete batches over a completed slab shall not be permitted until the slab has reached its specified compressive strength. If carts are used, timber planking shall be required for the remainder of the curing period. Carts shall be equipped with pneumatic tires. Curing operations shall not be interrupted for the purpose of wheeling concrete over finished slabs.

702.5.8.2. Vibration. Successive layers or adjacent portions of concrete shall be placed in a sequence so that they can be vibrated into a homogeneous mass with the previously placed concrete without a cold joint. No more than one hour shall elapse between adjacent or successive placement of concrete. Unauthorized construction joints shall be avoided by placing required portions of abutments, piers, walls or superstructure in one continuous operation. For mass placements, placements on false-work where differential setting time may include stress cracking, placement in deep girder stems, etc., an approved retarder (cement dispersing agent) in accordance with Item 702.2.3. Concrete Additives and Modifiers (Chemical Admixtures) shall be used to control stress cracks and/or unauthorized cold joints.

All concrete shall be well consolidated and the mortar flushed to the surface of the forms by continuous working with mechanical vibrators of an approved type. Vibrators of the type which operate by attachment to forms or reinforcement shall not be permitted, except that external vibration may be allowed when the forms are of steel, but shall be subject to regulation by the OWNER.

At least one standby vibrator shall be provided for emergency use in addition to ones required for placement.

For lightweight concrete, vibrators of the high-frequency type, which produce a minimum of 7,000-impulses-per-minute, shall be required.

The vibrators shall be applied to the concrete immediately after deposit. Prior to the beginning of work, a systematic spacing of the points of vibration shall be established to insure complete consolidation of the concrete being placed and the thorough working of the concrete around the reinforcement, embedded fixtures and into the corners and angles of the forms. Immersion type vibrators shall be inserted vertically, at points 18-in. to 30-in. apart and slowly withdrawn.

For shallow slabs or for concrete inaccessible to vertical insertion of the vibrator, the vibrator may be inserted in a sloping horizontal position. The entire depth of each lift of concrete shall be vibrated, and the vibrator shall be allowed to penetrate several inches into the preceding lift of plastic concrete. New concrete placed against hardened concrete or against fresh concrete that is not plastic shall be thoroughly consolidated along the joint surface. The vibration shall be of sufficient duration to produce thorough consolidation and complete embedment of reinforcement and fixtures but shall not be done to an extent that shall cause segregation. Vibration may be supplemented by hand spading or rodding, if necessary, to insure the flushing of mortar to the surface of all forms.

702.5.8.3. Fogging. For Curing methods, see Item 702.5.10.2.2. Water Curing.

702.5.8.4. Placing Concrete Under Adverse Weather Conditions. Concrete placement shall not be permitted when impending weather conditions may result in rainfall or low temperatures which shall impair the quality of the finished work. In case rainfall should occur after placing operations are started, the CONTRACTOR shall provide ample covering to protect the work. In case of a drop in temperature, the provisions set forth herein shall be applied.

Concrete for structures shall not be placed on frozen ground nor shall it be mixed or placed while the atmospheric temperature is below 40°F, unless adequate means are employed to heat the aggregates and water and satisfactory provisions have been made for protecting the work.

Concrete slabs shall not be placed on frozen ground, nor shall concrete be mixed or placed when the atmospheric temperature is below 40°F or when conditions indicate that the temperature may fall to 40°F within a 24 hour period, except with the written permission of the OWNER and only after such precautionary measures for the protection of the work have been taken as the OWNER may direct.

Concrete shall be effectively protected from freezing or frost for a period of 5 days after placing. When the temperature of the air is above 85°F, an approved retarding mixture shall be required in all concrete used in superstructures, top slabs of direct traffic culverts and cased drilled shafts.

Concrete placement shall be stopped when rainfall is sufficient to cause damage to the work.

702.5.8.5. Placing Concrete in Water. Concrete shall be deposited in water only when specified on the plans or with written permission of the OWNER. The forms, cofferdams or caissons shall be sufficiently tight to prevent any water current passing through the space in which the concrete is being deposited. Pumping shall not be permitted while the concrete is being placed, or until it has set for at least 36-hours.

The concrete shall be placed carefully in a compact mass by means of a tremie or other approved method that does not permit the concrete to fall through the water without adequate protection. The concrete shall not be disturbed after being deposited. Depositing shall be regulated to maintain approximately horizontal surfaces at all times.

When a tremie is used, it shall consist of a tube having a diameter of not more than 10-in., constructed in sections having watertight connections. The tremie shall be equipped with a device for sealing the bottom of the tube, the positive opening thereof and for the placing of the tremie through the water to the point of placement. The means of supporting the tremie shall permit the movement of the discharge over the entire surface of the work and shall permit the tremie to be lowered rapidly when necessary to choke off or retard the flow.

702.5.8.6. Placing Concrete in Superstructure. To insure operation and maintenance of grades and clearances, one or more passes of the screed shall be made over the section of bridge spans to be placed prior to the placement of concrete.

For transverse finishing, concrete in the superstructure shall be placed in transverse strips, beginning at the lowest end of the unit or length of spans to be placed and proceeding to the other end.

For longitudinal screeding, concrete shall be placed in longitudinal strips. Placing, preferably, shall be started at a point in the center of the section adjacent to one curb. The strip thus started shall be completed by depositing concrete uniformly in both directions toward the ends except that for spans on a grade of $1^1/_2$-percent or more, the placing shall start at the lowest end. The width of strips shall be such that the concrete therein shall remain plastic until the adjacent strip is placed.

The forms for the bottom surface of concrete slabs, girders and overhangs shall be maintained true to the required vertical alignment during the concrete placing. For convenience in checking the vertical alignment, an approved system of “tell-tales” attached to the forms shall be installed and maintained by the CONTRACTOR. They shall provide a convenient means of match-marking with reference to points set on stakes or other suitable reference points set independently of the forms and false-work for the span being placed. Unless otherwise provided, the girders, slab and curbs of deck girder spans shall be placed in one continuous operation.

The filling of girder stems ahead of placing the concrete in the slab shall be permitted, provided the slab concrete is placed in the time as specified in Item 702.5.8.1. General. The location of construction

joints and the sequence of placements of the slab on steel and prestressed concrete beams shall be as shown on the plans. Where plans do not specify a particular sequence, any logical placing sequence which shall not result in the over-stressing of any of the supporting members shall be permitted subject to the approval of the OWNER.

On steel truss spans the false-work under the span shall be released and the span swung free on its permanent supports before placing any concrete in the floor slab.

As soon as concrete is placed in a section of the slab of sufficient width to permit finishing operations, the slab shall be finished as specified in Item 702.5.13. Finishing Exposed Surfaces. When the surface of the slab is to receive an additional wearing surface or level-up (widening), the slab shall be given a reasonably smooth float or screed finish and shall not be finished as stated above.

702.5.8.7. Placing Concrete in Box Culverts. In general, construction joints shall be permitted only at the points shown on the plans.

Where the top slabs and side-walls are placed monolithically in culverts more than 4-ft. in clear height, an interval of not less than 1-hour nor more than 2-hours shall elapse between the placing of the concrete in the walls and that in the top slab. Such interval is to allow for shrinkage in the wall concrete.

The top surface of the base slab shall be finished accurately at the proper time to provide a smooth uniform surface. The upper surface of the top slab which shall carry direct traffic shall be finished as specified for finishing roadway slabs in Item 303.5.6. Finishing. On a fill-type culvert which does not carry direct traffic, the top slab shall be given a reasonably smooth finish.

702.5.8.8. Vaults. Vaults shall be provided as specified and/or detailed for access to manholes, gate valves, air release valves, etc.

702.5.8.8.1. Construction. Vaults may be of concrete, reinforced concrete, or precast reinforced concrete pipe as detailed in Item 501.6. Reinforced Concrete Culvert, Storm Drain, Pipe and Box Section or as shown on the project plans. General construction shall include the following:

(1) Vaults used for blow-off manhole applications shall be of water containment construction, utilizing either the monolithic pour-in-place concrete or precast reinforced concrete pipe with trapped O-ring gasket as further defined in Item 501.6. Reinforced Concrete Culvert, Storm Drain, Pipe and Box Section.

(2) Vaults used for non-water containment construction, such as for valve installations, shall be either pour-in-place 2500# reinforced concrete or precast reinforced concrete tongue-and-groove design pipe meeting ASTM C76 Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe, Class III, using trapped O-ring type rubber seals.

(3) Material requirements for vaults shall be as controlled under the material requirements of these specifications and the contract documents, as applicable, with specific inference placed on material specifications.

Walls. For in-place vaults, walls shall be formed on all sides to the thickness specified. Unless specified otherwise, walls shall not be less than 6-in. thick.

Top Slabs and Grade Adjustment. Top slabs shall normally be poured below final grade and grade rings used to achieve final grade ring elevations. Manhole grade rings, covers, vents, etc. shall be installed as detailed in Item 502.1. Manholes, shown on project plans, or as directed by the OWNER.

Finish. The vault top slab invert and inside wall shall be given a rubbed finish in accordance with Item 702.5.13. Finishing Exposed Surfaces.

702.5.8.8.2. Testing. Water-containment vault structures shall be tested for exfiltration as required in Item 507.5.1.2. Exfiltration of this specification. In the event that leakage occurs in excess of allowable limits, the vault shall be completely sealed with an approved mastic sealer. Any visible seepage of free water shall require sealing on either water containment vaults or manholes.

702.5.8.8.3. Measurement and Payment for Vaults. Measurement and payment for vaults shall be as hereinafter defined, unless specified otherwise in the special contract documents.

Measurement for vault structures shall be on a per each basis complete in place with all accessories and shall include appurtenant work including excavation through backfill to provide for the structure complete in place as designed for the project. Each vault structure is to be complete in place with all system components to be housed as further outlined as follows:

(1) Access Manhole Vault. Since the flanged access outlet and cover are usually furnished as a fitting for concrete cylinder pipe, the vault shall be the only item considered for payment under this bid item category in the proposal.

(2) Air Valve or Combination Air and Vacuum Release Valve in Vault. Payment under this bid item category in the proposal shall include furnishing and installing the air valve or combination air and vacuum release valve, together with all subsidiary piping valves and other appurtenances complete in place as detailed as well as construction of the vault structure. The connecting taps on the main shall be included in the bid price for furnishing and installing fittings or shall be subsidiary to the price bid for furnishing and installing pipe, whichever is more applicable for a specified project.

(3) Gate Valve in Vault. Payment under this bid item category in the proposal shall include the construction of the vault as well as furnishing and installing the gate valve complete in place on concrete blocking along with all appurtenances as detailed for complete and functional installation.

(4) Blow-off and Vault. Payment under this bid item category in the proposal shall include the construction of a water containment vault structure as well as furnishing and installing piping (exclusive of the M.J. bell outlet on concrete mains or M.J. tee on cast iron mains), valves, blocking and other appurtenances as detailed with polyethylene wrapping.

702.5.8.9. Placing Concrete in Foundations and Substructure. Concrete shall not be placed in footings until the depth and character of the foundation has been inspected by the OWNER and permission has been given to proceed.

The placing of concrete bases above seal courses shall be permitted after the caissons or cofferdams are free from water and the seal course cleaned. Any necessary pumping or bailing during the concreting operations shall be done from a suitable sump located outside the forms.

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

When footings can be placed in dry foundation pits without the use of cofferdams or caissons, forms may be omitted, if desired by the CONTRACTOR and approved by the OWNER, and the entire excavation filled with concrete to the elevation of the top of footing. Where this procedure is followed, no measurement for payment shall be made for concrete placed outside of the footing dimensions shown on the plans.

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

702.5.9. Finishing Concrete. All upper horizontal surfaces not covered by forms shall be struck off to grade and finished. The use of mortar topping for surfaces under this classification shall not be permitted.

After concrete has been struck off as described above, the surface shall be floated with a suitable float. Bridge sidewalks shall be given a wood float or broom finish or may be striped with a brush, as specified by the OWNER. Unless otherwise specified, top of caps and piers shall be given a smooth finish with a steel trowel. Other surfaces shall be wood float finished and striped with a fine brush leaving a fine-grained texture.

702.5.10. Curing Concrete. Careful attention shall be given to the proper curing of all concrete. CONTRACTOR shall inform OWNER fully of the methods and procedures proposed for curing, shall provide proper equipment and material in adequate amounts, and shall have approval of the proposed method, equipment and material prior to placing concrete.

Inadequate curing facilities or lack of attention to the proper curing of concrete shall be cause for OWNER to stop all construction on the job until approved curing is provided.

702.5.10.1. Curing Period. All concrete shall be cured for a period of time noted in Table 702.5.10.1.(a) Curing Period, unless otherwise specified by the OWNER. In continuous placement of concrete, the required curing period shall begin when all concrete has been placed and has attained its initial set.

Table 702.5.10.1.(a) Curing Period

Concrete Structure	Curing Days[1,2]
Top Slabs of Direct Traffic Culverts	8-days
Other Structures	4-days

1. A curing day is defined as a day when the ambient temperature, taken in the shade away from artificial heat, is above 50°F for at least 19-hours, or the ambient temperature is 50°F or less; and if satisfactory provisions are made to maintain the temperature at all surfaces of the concrete above 40°F for the entire 24-hours.
2. In addition, concrete must meet 75-percent of the minimum compressive strength requirements.

702.5.10.2. Curing Methods. The following methods are permitted for curing concrete subject to the restrictions of Table 702.5.10.2.(a) Curing Methods, and the requirements of this specification for each method of curing.

Table 702.5.10.2.(a) Curing Methods

Structure Unit Description		REQUIRED		PERMITTED	
		Water for Complete Curing	Membrane for Interim Curing	Water for Complete Curing	Membrane for Interim Curing
1.	Top slabs of direct traffic culverts, top surface of any concrete unit upon which concrete is to be placed and bonded at a later interval (stub walls, risers, etc.). Other superstructure concrete (wing-walls, parapet walls, etc.).	X			
2.	Top surface of precast and/or prestressed piling	X	X		
3.	All substructure concrete, culverts, box sewers, inlets, manholes, retainer walls, riprap.			X[1]	X[1]

1. Polyethylene sheeting or burlap polyethylene mats fastened to prevent outside air from entering shall be considered equivalent to water or membrane curing per this item.

702.5.10.2.1. Form Curing. When forms are left in contact with the concrete, other curing methods shall not be required except for cold weather protection.

702.5.10.2.2. Water Curing. All exposed surfaces of the concrete shall be kept wet continuously for the required curing time. The water used for curing shall meet requirements for concrete mixing water as specified in Item 303. Portland Cement Concrete Pavement.

Wet Mat. Cotton mats shall be used for this curing method. The mats shall not be placed in contact with the concrete until such time that damage shall not occur to the surfaces. Damp burlap blankets made from 9-oz. stock may be placed on the damp concrete surface for temporary protection prior to the application of the cotton mats. The mats may be placed dry and wetted down after placement. Mat curing, except for continuous placements, shall commence not later than 3-hours after finishing the roadway slab. The mats shall be weighted down adequately to provide continuous contact with all concrete surfaces where possible. The surfaces of the concrete shall be kept wet for the required curing time. Surfaces which cannot be cured by contact shall be enclosed

with mats, anchored positively to the forms or to the ground, so that outside air cannot enter the enclosure to keep all surfaces of the concrete wet.

Water Spray. This method shall be accomplished by overlapping sprays or sprinklers, so that all unformed surfaces are kept continuously wet.

Ponding. This method requires the covering of the surfaces with a minimum of 2-in. of clean granular material, kept wet at all times, or water to a minimum depth of 1-in. Satisfactory provisions shall be made to provide a dam to retain the granular material or water.

Fogging. All the unformed surfaces of slab concrete for bridge decks and the top slab of direct traffic culverts shall be protected against rapid surface drying by the use of fog sprays. Fog sprays, powered by pressure pumps and capable of covering the entire area of freshly placed concrete with a fine mist, shall be installed, ready for use prior to the start of placing operations.

On individual placements of 15-cubic-yards or less, hand operated spray nozzle equipment of the stirrup pump type may be substituted for the equipment specified above.

Fogging shall be carefully controlled to prevent accumulation of standing or flowing water on the surface of the fresh concrete. Fogging shall continue, as required, through the finishing operations and shall be used as interim curing until the selected curing medium is in place, except that in lieu of continuous fogging over the entire area, that portion of the finished concrete surface which is sufficiently hardened may be covered with wet burlap. The burlap shall be kept wet until the final curing media is in place.

702.5.10.2.3. Membrane Curing. Membrane curing shall not be applied to dry surfaces but shall be applied to horizontal surfaces just before free moisture has disappeared. Formed surfaces and surfaces which have been given a first rub shall be dampened and shall be moist at the time of application of the membrane. Unless otherwise shown on the plans, Type 2 membrane curing compound in accordance with Item 303.2.13. Curing Materials may be used where permitted. Membrane shall be applied in a single, uniform coating at the rate of coverage recommended by the manufacturer and as approved by the OWNER. Tests for acceptance shall be at the specified rate of application.

When membrane is used for complete curing, the film shall remain unbroken for the minimum curing period specified. Membrane which is damaged shall be corrected immediately by re-application of membrane.

702.5.11. Removal of Forms and False-Work. Except as herein provided, forms for vertical surfaces may be removed when the concrete has aged not less than 1 curing day. A curing day is defined as a day when the ambient temperature, taken in the shade away from artificial heat, is above 50°F for at least 19-hours, or the ambient temperature is 50°F or less; and if satisfactory provisions are made to maintain the temperature at all surfaces of the concrete above 40°F for the entire 24-hours.

Weight supporting forms and false-work for all bridge components, culverts and slabs shall remain in place a minimum of 4-curing-days. Forms may then be removed if the concrete has attained 75-percent of design strength, as evidenced by strength tests using test specimens made from the same concrete and cured under the same conditions as the portion of the structure involved. Forms for other structural components may be removed as specified by OWNER. If all test specimens made for the purpose of form removal have been tested without attaining the required strength, forms shall remain in place for a total of 14-curing-days.

The above provisions relative to form removal shall apply only to forms or parts of forms which are so constructed as to permit removal without disturbing forms or false-work which are required to be left in place for a longer period on other portions of the structures.

702.5.12. Defective Work. Any defective work discovered after the forms have been removed shall be repaired or replaced as soon as possible. If the surface of the concrete is bulged, uneven or shows excess honeycombing or form marks which in the opinion of the OWNER cannot be repaired satisfactorily, the entire section shall be removed and replaced. In repairing honeycombed areas, all loose material shall be removed before the repair work is started. No extra compensation shall be allowed for extra work or materials involved in repairing or replacing defective concrete.

702.5.13. Finishing Exposed Surfaces. The type of surface finish shall be one of the types described herein and as designated on the plans. Where the plans do not specify the type of finish, a Type 1 Finish shall be required.

702.5.13.1. Type 1 Finish. The following areas shall require lined forms and shall receive a first and second rubbing:

(1) The top, exterior and roadway faces of curbs; all concrete surfaces of railing, including the parapet types; the exterior vertical faces of slab spans, rigid frames, arches and box girders; the outside and bottom surfaces of fascia beams or girders (precast prestressed concrete beams excluded); the underside of overhanging slabs to the point of juncture of the supporting beam; all vertical surfaces of piers, columns, bent caps, (including the bottom sloped portions only of variable depth caps), abutments, wing-walls and retaining walls, which are exposed to view after all backfill and embankment are placed.

(2) On slab spans and rigid frame structures, the underside of the slab shall be finished for a width of 2-feet in from the outer edge, but lined forms shall be required for the entire bottom surfaces.

(3) For rigid frame structures, finishing shall be required on the inside sloping and vertical surfaces.

(4) Culvert headwalls and wing-walls, inlets, manholes and sewer appurtenances shall receive a first rubbing only.

No rubbing shall be required on any area inside culvert barrels. Horizontal surfaces of bridge sidewalk slabs shall be finished in accordance with Item 303.5.6. Finishing.

702.5.13.2. Type 2 Finish. All concrete surfaces of railing, including the parapet types, the top and roadway faces only of curbs, and wing-walls of bridges shall be given a first and second rubbing. All other surfaces described under Type 1 Finish shall be given a first rubbing only. Lining of forms shall be as required in a Type 1 Finish.

702.5.13.3. Type 3 Finish. All concrete surfaces of railing, including the parapet types, the top and roadway faces only of curbs, and wing-walls of bridges shall be given a first and second rubbing. All other surfaces described under Type 1 Finish shall not require rubbing but shall require lining of forms.

702.5.13.4. Type 4 Finish. All concrete surfaces of railing, including the parapet types, the top and roadway faces of curbs, and wing-walls of bridges and culverts shall be given a first rubbing only. Form lining shall not be required. Rubbing of culvert wing-walls shall not be required, provided lined forms are used.

702.5.13.5. Surface Finishing Methods. The first rubbing shall be done immediately upon removal of the forms. Membrane curing, if used, shall be applied after the first rub has been completed. Prior to the second rubbing, any remaining curing membrane shall be removed from the surface by brushing, buffing or other satisfactory methods. Removal of the membrane shall not be required except when a second rubbing is required.

After all repair work and pointing has set sufficiently, rubbing shall be performed as follows:

(1) All surfaces to be finished shall be wet and given a first rubbing with a carborundum stone. The rubbing shall bring the surface to a paste and produce a smooth dense surface without pits, form marks or other irregularities. The use of cement to form a paste shall not be permitted.

(2) Where a single rubbing is specified, the paste shall be spread uniformly, striped with a brush and allowed to take a reset, after which the surfaces shall be washed with clean water, leaving them with a neat and uniform appearance and texture. Chamfered corners shall also be rubbed.

(3) When a second rubbing is required, striping with a brush and washing after the first rubbing shall not be required. Chambered corners generally should not be rubbed in the first rubbing.

(4) The second rubbing shall be performed during the process of conditioning the structure for final acceptance. The surfaces requiring finish shall be cleaned of drip marks and discolorations and shall be given a final rubbing with a carborundum stone. The surface shall be striped neatly with a brush, and the mortar shall be allowed to take a reset, after which the surfaces shall be washed with clean water, leaving them with a neat and uniform appearance and texture.

Surfaces other than those specified herein shall not require rubbing unless they are not true or have porous or honeycombed areas which are not designated for replacement. When such defects occur,

the areas affected shall be given a first rubbing, which shall extend over a sufficient area to blend it into the surrounding unfinished surface. This shall not be construed to require the rubbing of large adjacent unblemished areas to gain absolute uniformity of color and texture on the structure part in question. All surfaces shall be free of discolorations and should present a uniform appearance. Unsightly discoloration shall be removed prior to acceptance.

702.5.13.6. Painting in Lieu of Rubbing. When so indicated on the plans, or with written permission of the OWNER, painting of concrete surfaces in lieu of rubbing shall be permitted. When painting is permitted, it shall be accomplished as follows or as according to the OWNER:

(1) Soon after form removal, any porous spots, honeycombed areas, untrue surfaces and lines shall be corrected. All fins, form marks, runs, drips or mortar shall be removed, leaving a smooth and uniform surface.
(2) When preparing the completed structure for final acceptance, all grease, dirt, mortar drips and remaining curing membrane shall be removed from the pertinent surfaces.
(3) Surfaces shall be painted with a latex-base adhesive grout. The grout shall consist of one part latex-base adhesive, two parts white cement, two parts natural cement, two parts fine masonry sand and one part water. Mixture should have the consistency of a thick paint.
(4) The finished surface shall have a uniform appearance and texture. Thickness of coating shall be approximately $^{1}/_{16}$-in. to $^{1}/_{8}$-in.

702.5.14. Measurement and Payment. The quantity of concrete which constitutes the completed structure shall be measured by the cubic yard of accepted work in place. The dimensions used shall be those shown on the plans or ordered in writing by the OWNER. No deductions in measurement shall be made for embedded reinforcing steel or for embedded portions of structural steel members.

The concrete quantities, measured as provided, shall be paid for at the unit price bid per cubic yard for concrete, which price shall be full compensation for furnishing, hauling and mixing all concrete materials, including trial batches; placing, curing and finishing all concrete; all grouting and joints; furnishing and placing all expansion and construction joints, except as hereinafter provided; furnishing and placing metal flashing strips and waterstops; and all forms and false-work, labor, tools, equipment and incidentals necessary to complete the work.

The above provision for payment for expansion joints shall not be interpreted to provide payment for cast steel or structural steel shapes and plates, used expansion joints and armored joints, or for structural steel, cast iron or cast bearing plates. Payment for these materials shall be as provided for in Item 806. Metal Materials.

The preceding provisions for payment shall not be interpreted to provide payment for concrete in railing, piling, precast prestressed concrete units or other concrete items for which provision is otherwise made in these specifications or in the contract documents.

702.6. PRESTRESSED CONCRETE FOR STRUCTURES

702.6.1. Description. This item shall govern the complete construction, furnishing, storing, handling and erection of precast prestressed concrete structures, in accordance with the plans, with the exception of piling, which shall be in accordance with Item 704.1.2. Concrete Piling. For additional information, refer to TxDOT Specifications and OWNER-provided specifications.

702.6.2. General. The method of construction and of prestressing shall be as shown on the project plans and on the approved shop drawings. Prior to beginning the casting of prestressed members, the CONTRACTOR shall give the OWNER notice.

702.6.3. Materials. Materials for concrete shall be in accordance with Item 702.2. Concrete Structure Materials, and Item 702.3. Mix Design and Mixing Concrete for Structures. Reinforcing steel, not prestressed, shall conform to the requirements of Item 303.2.9. Steel Reinforcement. Structural steel bearing plates, fittings, etc. shall be in accordance with Item 806. Metal Materials. Bearing pads shall be in accordance with TxDOT Item 435. Elastomeric Materials and with special specifications contained in the Contract.

702.6.4. Handling and Erection. Fabrication and erection plans shall indicate the method of handling and erecting prestressed members. An adequate factor of safety shall be included in all calculations for handling and erection to preclude over-stressing any part of the member due to dynamic forces or impact.

Prestressed concrete beams shall be maintained in an upright position at all times and shall be picked up and supported near the end of the beams only and in such a way as to prevent torsional stress in the beam. Beams may be lifted with the lifting devices as approved on the shop plans or by other methods approved by the OWNER in writing.

No prestressed concrete structural member shall be moved from the casting yard until all requirements for tensioning, curing and strength have been attained. The strength of a prestressed member shall be considered adequate after curing and tensioning requirements are fulfilled if the design strength compressive cylinders indicate that the required design strength has been attained.

702.6.5. Defects and Breakage. If any prestressing tendon or portion thereof is broken prior to placing concrete in the member, it shall be replaced with a satisfactory unit properly prestressed at no cost to the OWNER. The breaking of one wire of a 7-wire strand in a unit during concrete placing operations shall be subject to a structural review prior to acceptance.

Fine hair cracks or checks on the surface of the member which, as determined by the OWNER, do not extend to the plane of the nearest reinforcement, shall not be cause for rejection unless such cracks are so numerous and extensive as to indicate inadequate curing, in which case the members shall be rejected. Diagonal cracks on the vertical surfaces which indicate damage from torsion shall be subject to a structural review prior to acceptance or rejection by the OWNER. Vertical and horizontal cracks which are $^{1}/_{16}$-in. or less in width and which tend to close upon release of stress are acceptable. Cracks in excess of this are subject to review prior to acceptance or rejection by the OWNER. Cracks which extend into the plane of reinforcing steel and/or prestressed tendons and are acceptable otherwise shall be repaired by sealing with a latex-base adhesive grout or with epoxy.

All replacements as herein specified as well as all other replacements due to faulty materials or construction methods shall be made at the CONTRACTOR'S expense.

702.6.6. Workmanship and Tolerance. Variations greater than specified shall be cause for rejection.

702.6.6.1. Prestressed Beams, Girders, Spans and Box Type Beams. Requirements shall include the following:

(1) variation from shop plan lengths: plus or minus 1-in.
(2) variation from plan height, box type beams: plus or minus ¼-in. Others: plus or minus ½-in. maximum deviation of ¼-in. per 10-ft. of length. Box-type beams ¾-in total deviation.
(3) out-of-square (vertical or horizontal) or deviation from plane skew angle: maximum ⅛-in.-per-ft. of dimension.
(4) bearings. Requirements include:
  (a) out-of-perpendicular with vertical axis: maximum $^{1}/_{16}$-in.
  (b) honeycomb in bottom soffit of beams at the bearing shall not exceed 15-percent of the bearing area (width x length). No tendon shall be exposed and the maximum depth of honeycomb shall not exceed 1-in. Honeycomb shall be chipped out to sound concrete and repaired satisfactorily prior to acceptance.
(5) form fit-up. Where sections of forms are to be butt-jointed, an offset of $^{1}/_{16}$-in. for flat surfaces and ⅛-in. for corners and bends shall be permitted.

702.6.6.2. Repair. Small areas of honeycomb which are purely surface in nature (not over 1-in.) may be repaired. Honeycomb extending to the plane of the prestressed strands shall be rejected tentatively, subject to structural review prior to acceptance or rejection by the OWNER.

702.6.6.3. Steel. Reinforcing steel shall not project above the top of the member more than ½-in. nor less than ¾-in. from plan dimension. In the plane of the steel parallel to the nearest surface of concrete, bars shall not vary from plan placement by more than ¼-in. or $^{1}/_{12}$ of the spacing between bars, whichever is greater. In the plane of the steel perpendicular to the nearest surface of the concrete, bars shall not vary from plan placement by more than ¼-in.

702.6.7. Measurement and Payment.

702.6.7.1. Measurement. Precast, prestressed concrete beams or girders of the type specified, cast and stressed, as required on the plans, shall be measured by the linear foot complete in place.

Precast, prestressed concrete spans of the size and type specified, cast and stressed, as required by the plans, shall be measured as each prestressed span, complete in place.

Other precast, prestressed members of the type and size specified, cast and stressed, as required by the plans, may be measured by the linear foot or by each member as the case may be and as noted on the plans.

Cast-in-place structures (or structures where the CONTRACTOR has the option of casting-in-place) shall be measured as follows:

(1) concrete, non-prestressed reinforcing steel and structural steel (except bearing and anchorage devices integrally a part of the post-tensioning system) shall be measured by the cubic yard or by the pound in accordance with the applicable specifications for these items. Grout and ducts for post-tensioning shall not be measured but shall be considered subsidiary to this item.

(2) the prestressing steel required and the work involved in the prestressing of the cast-in-place structures or units shall not be measured but shall be considered as one unit for "prestressing" each different structure type or unit as itemized on the plans and in the proposal.

702.6.7.2. Payment. Precast, prestressed concrete beams or girders shall be paid for at the unit price bid per linear foot (m) for "prestressed concrete beams" of the type specified.

Precast, prestressed concrete spans shall be paid for at the unit price bid for each "prestressed concrete span."

Other prestressed concrete members shall be paid for at the unit price bid per linear foot for "prestressed concrete members" (specify name and type) as the case may be.

A partial allowance shall be made for materials and for precast or prestressed concrete members cast, but not erected.

The above prices shall be full compensation for constructing the member; furnishing and tensioning prestressed steel; furnishing and placing reinforcing steel, conduit and attached bearing plates, etc. for same; grouting holes; and for all bars, anchorage plates, and other appurtenances which become an integral part of the precast structure and for any special treatment of end anchorages and shoes as indicated on the plans; and for furnishing all materials, tools, equipment, labor and incidentals necessary to fabricate, transport and erect the members in the structure as indicated on the plans. The cost of all materials used in the test specimens and the cost of providing and maintaining curing facilities shall be included in the unit price bid for the various prestressed concrete members.

702.7. PNEUMATICALLY PLACED CONCRETE (GUNITE)

702.7.1. Description. Pneumatically placed concrete shall consist of premixed sand and Portland cement pneumatically transported through a pipe or hose in a dry state to a nozzle where hydration takes place immediately prior to expulsion. For additional information, refer to TxDOT Specifications and OWNER-provided specifications.

702.7.2. Materials. The concrete shall conform to the requirements of Item 702.2. Concrete Structure Materials. Bar reinforcement and wire fabric reinforcement shall conform to the requirements of Item 303.2.9. Steel Reinforcement. Expansion joints shall conform to the relevant requirements Item 303. Portland Cement Concrete Pavement.

Steel drive pins or studs used for the attachment of reinforcing when covering designed portions of concrete structures with pneumatically placed concrete shall be capable of being driven to the specified depth without deforming or otherwise becoming unsuitable for the purpose intended. The pins shall have a minimum diameter of $^1/_8$-in. and a minimum length of 2-in. Size and location of drive pins or studs and method of attachment of reinforcing shall be as specified herein or as detailed on the plans.

702.7.3. Equipment and Workers. The gun mechanism should be operated at a minimum air pressure of 45-psi on the gun tank when 100-ft. or less of material hose is used and the pressure should be increased 5-psi for each additional 50-ft. of hose required. Nozzles used for guniting shall have a maximum size of 1⅝-

in. unless otherwise permitted by the OWNER. Water used for hydration shall be maintained at a uniform pressure, which shall be at least 15-psi above air pressure at the gun.

The equipment used for driving the pins or studs shall be of the type which uses an explosive for the driving force and shall be capable of inserting the stud or pin to the required depth without damage to the concrete. The OWNER may require that a test be made of equipment prior to approving it for use.

Only experienced foremen, gunmen, nozzlemen, and rodmen shall be employed, and satisfactory written evidence of such experience shall be furnished to the OWNER or its representative upon demand.

702.7.4. Proportions, Mixing, and Testing. Unless otherwise specified, the concrete shall consist of a mixture of cement and sand in the proportions by volume of 1 part of cement to 4½ parts of sand.

The sand shall contain not less than 3-percent nor more than 6-percent moisture by weight. The sand and cement shall be mixed thoroughly in a power mixer for at least 1½-minutes before placement in the chamber of the gun mechanism. The dry mixed material shall be used promptly after mixing. Any material that has been mixed for more than 45-minutes shall be rejected and removed from the worksite.

The use of approved admixtures conforming to the requirements of Item 702.2.3. Concrete Additives and Modifiers shall be permitted at the option of the CONTRACTOR.

The mixer shall be cleaned at regular intervals to remove all adherent material from the mixing vanes and from the drum.

At the beginning of work the OWNER may require that cylinders be made to represent the quality of the pneumatically placed concrete. Additional cylinders shall be made during performance of the work as directed by the OWNER. If in the opinion of the OWNER, the cylinder strengths are indicating undesirable variation in the concrete, the CONTRACTOR may be required to change the mix design and/or method of placing so as to correct this condition. The CONTRACTOR shall furnish specially constructed cylinders 6-in. in diameter and 12-in. high, made of ¾-in square mesh hardware cloth. Test cylinders for pneumatically placed concrete shall be shot with the same air pressure and nozzle tip as the pneumatically placed concrete. At the end of the first 24-hour curing period, the hardware cloth form shall be removed and the cylinders stored and cured as directed by the OWNER.

702.7.5. Construction Methods. Concrete shall not be applied to a surface containing frost or ice. Where standing or running water is encountered, it shall be removed before applying the concrete. No work shall be done without the permission of the OWNER when the temperature is lower than 40°F. After placing, the concrete shall be protected from freezing or quick drying.

702.7.5.1. Placement. Earth surfaces to which concrete is to be applied shall be neatly trimmed to line and grade and shall be free of all loose material. The surface need not be compacted by slope rolling or other measure unless required by the plans or specifications.

No high subgrade shall be permitted. Excavation made below subgrade shall be backfilled with compacted fill or, at the CONTRACTOR'S option, with concrete. However, no additional compensation shall be allowed for such compacted fill nor for increased thickness of concrete placed because of low subgrade.

Asphaltic concrete surfaces shall be thoroughly cleaned of any organic material, silt and clay, or any other material detrimental to the concrete and then washed with water under pressure. Masonry, rock and concrete surfaces shall be examined and all loose material removed therefrom. The surface shall be thoroughly cleaned with steel scrapers or brushes to remove all dust, dirt, mortar, grease or other deleterious substances and then washed with water. Whenever brushing and scraping do not secure suitable results, sandblasting may be required.

All surfaces shall be wetted with water before application of concrete. Concrete shall not be applied to surfaces on which free water exists.

The velocity of the material as it leaves the nozzle shall be maintained uniformly at a rate determined for given job conditions. Material which rebounds and does not fall clear of the work, or which collects on the surfaces, shall be blown off or otherwise removed. Rebound shall not be used in any portion of the work, and no payment shall be made for rebound or other concrete losses.

The nozzle shall be held at such distance and position that the stream of flowing material shall impinge at approximately right angles to the surface being covered. Any portion of the placed concrete

which tends to sag or which shows soft or sandy pockets or is otherwise unsatisfactory shall be cut out and replaced with new concrete. Reinforcement damaged or destroyed by such repairs shall be replaced by trimming the concrete back and properly lapping and tying additional steel as may be required by the OWNER.

Reinforcement shall be firmly supported in the position shown on the plans. Mortar blocks, metal chairs, clips or spacers with wire ties or other acceptable means shall be used to anchor and place the reinforcement properly.

Where material is placed on overhead surfaces, the amount of water used shall be so adjusted that approximately $^3/_4$-in. of the placed material shall adhere without support. The limit of thickness shall be considered to have been exceeded when the material begins to sag or slough.

702.7.5.2. Forms and Ground Wires. The forms shall be built in accordance with applicable provisions of the specifications, except all forms shall be built so as to permit the escape of air and rebound.

Ground wires shall be installed in such a manner that they accurately outline the finished surfaces as indicated on the plans. They shall be located at intervals sufficient to insure proper thickness throughout. Wire shall be stretched tight and shall not be removed prior to application of the finish coat.

Headers shall be required where the plans indicate a formed edge and at plane joints.

702.7.5.3. Joints. Construction joints shall be sloped off at an angle of approximately 45° to the surface to which the concrete is being applied. Before applying concrete in the adjacent sections, the sloped portion shall be thoroughly cleaned and wetted by means of air and water blast.

The plane joints shall be formed in accordance with and placed in the locations designated on the plans.

702.7.5.4. Finish. Upon reaching the thickness and shape outlined by forms and ground wire, the surface shall be rodded off to true lines. Any low spots or depressions shall be brought up to proper grade by placing additional concrete. Ground wires shall then be removed. Unless otherwise specified, the surface shall then be broom finished to secure a uniform surface texture. Rodding and working with a wood float shall be held to a minimum.

Rebound or accumulated loose sand shall be thoroughly cleaned up and disposed of by the CONTRACTOR. In no case shall they be floated into the surface of the work.

When a nozzle finish is specified on the plans, ground wires shall not be used, and the surface shall be left as uniform as possible without rodding. Nozzle finish shall not be permitted where the underlay has been floated.

702.7.5.5. Curing. Pneumatically placed concrete shall be cured in accordance with Item 702.5.10.2. Curing Methods.

702.7.6. Measurement and Payment. Measurement for pneumatically placed concrete shall be made by the square foot in place. For encasement of structural steel members and covering portions of structures, the actual contact area shall be the basis for measurement.

Pneumatically placed concrete, measured as provided in this item, shall be paid for at the unit price bid per square-foot for “pneumatically placed concrete” of the type specified. The unit price bid per square-foot shall be full compensation for all cement, sand, water, reinforcement, furnishing and driving all steel drive pins, mixing and placing pneumatically placed concrete, and for all labor, tools, equipment and incidentals necessary to complete the work. Excavation for channel and canal lining shall be paid for in accordance with Item 203.2. Unclassified Excavation. Shaping and fine grading of channel or canal slopes and floors are not to be paid for directly but shall be included in the unit price bid for “pneumatically placed concrete.” When header-banks upon which “pneumatically placed concrete” is to be placed have been built by prior contract, excavation for shaping of slopes shall be paid for in accordance with Item 701.2. Structural Removal, Excavation, and Backfill.

702.8. DRILLED SHAFT FOUNDATIONS

702.8.1. Description. This item shall govern the construction of foundations consisting of reinforced concrete shafts with or without bell type concrete footings. Such foundations shall be constructed in

accordance with this item and in conformance with the details and governing dimensions shown on the plans.

702.8.2. Materials. All concrete materials and their preparations shall be in accordance with the requirements of Item 702.2. Concrete Structure Materials, Item 702.3. Mix Design and Mixing Concrete for Structures, and the additional requirements herein. All concrete shall be Class A or Class PA, as specified by the OWNER, unless otherwise shown on the plans.

When casing of the shaft is required, the following shall apply:

(1) The maximum size coarse aggregate shall be 1½-in.

(2) The elapsed time from beginning of placement of concrete in the cased portion of the shaft until extraction of the casing is begun shall not exceed 30 minutes. If a cement dispersing agent is used, this time shall not exceed one hour. If non-agitating equipment is used to haul the concrete from a central mixing plant, the elapsed time for discharge of concrete from the mixer to placement in the shaft shall not exceed 10-minutes. If a cement dispersing agent is used, this time shall not exceed 30-minutes.

(3) When the temperature of the air or concrete is above 85°F., an approved cement reactive polymeric dispersant shall be required in all drilled shaft concrete. Reinforcing steel shall conform to the requirements of Item 303.2.9. Steel Reinforcement.

702.8.3. Construction Methods.

702.8.3.1. Excavation. The CONTRACTOR shall do all excavation required for the shafts and bell footings, through whatever materials are encountered, and to the dimensions and elevations shown on the plans or required by the site conditions. Unless otherwise shown on the plans, all shafts shall be bored to plumb to a tolerance of 1-in. for depths up to and including 10-ft. For shafts over 10-ft., tolerance will be approved by OWNER. Shafts and bells shall be excavated so as to form a bearing area of the size and shape shown on the plans. Blasting methods shall not be used without prior written approval of the OWNER. If blasting methods are approved, methods shall conform to Item 203.2.7. Alternate Methods of Excavation.

The plans indicate the expected depths and elevations at which satisfactory bearing material shall be encountered; this information shall be used as a basis for the contract. If satisfactory foundation materials are not encountered at plan elevations, the footings may be raised or lowered as determined by the OWNER. Alterations in plan depths shall be made as judged proper to satisfactorily comply with the design requirements.

Casings shall be required for shaft excavations when such provision is necessary to prevent caving of the material or when necessary to shut off seepage water. Casings shall be of ample strength to withstand handling stresses, along with the pressure of concrete and of the surrounding earth or backfill materials, and shall be watertight. The inside diameter of the casing shall not be less than the normal size of the shaft. No extra compensation shall be allowed for the concrete required to fill an oversize casing or oversize excavation.

When the drilling operation reaches a point where caving condition and/or excess ground water is encountered, no further drilling shall be allowed until a construction method is employed which shall prevent any caving that tends to make the excavation appreciably larger than the size of casings to be used. Construction methods that control the size of the excavation, such as drilling in a mud slurry without the removal of cuttings, shall be permitted.

If the elevation of the top of the shaft is below ground level at the time of concrete placement, an oversize casing from ground elevation to a point below the top of the shaft shall be required to control caving of any material into the freshly placed concrete.

Any excavation for the footing bells or shafts beyond the lines required shall be backfilled with Class A or Class PA concrete as specified by the OWNER at the CONTRACTOR'S expense. Where casings are used, the CONTRACTOR shall be permitted to backfill around the upper portion of the casing with pea gravel or other granular material. Where a double casing is required for a portion of the shaft, no material shall be placed between the casings but rather this area shall be filled with Class A or Class PA concrete as specified by the OWNER.

Under normal operations when the casing is to be removed, the removal shall not be started until concrete placement is completed in the shaft. Movement of the casing for short pulls of a few inches or rotating of the casing shall be permitted. When unusual conditions warrant, the casing may be pulled in partial stages. In all cases a sufficient head of concrete shall be maintained at all times above the bottom of the casing to overcome hydrostatic pressure. Extraction of the casing shall be at a slow, uniform rate and the full pull shall be in a truly vertical direction. If any upward movement of the concrete and/or inside the casing occurs at any time during the pulling operations, the following criteria shall govern:

(1) if the upward movement is 1-in. or less, the casing shall be left in place. Vibration or rodding shall not be used to attempt to break the casing loose for extraction unless the entire shaft is to be replaced.
(2) if the upward movement is greater than 1-in., all of the material shall be removed and the entire drilled shaft operation shall be redone.

Placing of drilled shaft concrete under water shall not be done without the permission of the OWNER.

Material excavated from shafts and bells and not used in the backfill around the completed bents or piers shall be disposed of as directed by the OWNER. The disposal of such material shall be in such manner as not to impair adjacent water bodies or otherwise impair the efficiency or appearance of the structure or other parts of the work.

At the time concrete is placed, the excavation shall be free from accumulated seepage water and all loose material shall be removed from the base area.

The CONTRACTOR shall provide suitable access and lighting for the OWNER to inspect the completed foundation excavation and check the dimensions and alignment of drilled shafts and the under-reamed excavation when under-reaming is required. Any required lighting shall be by electric lights. Any mechanical equipment used in the excavations shall be operated by air or electricity. The use of gasoline-driven engines placed in the excavation for pumping or drilling shall not be permitted.

In order that the OWNER may judge the adequacy of a proposed foundation, the CONTRACTOR, if requested, shall make soundings or take cores at its expense to determine the character of the supporting materials. The depth of such soundings or cores shall not be required to exceed 5-ft. below the proposed footing grade. It is the intent of this provision that soundings shall be made or cores taken at the time the excavation in each foundation is approximately complete.

When the plans require drilled shafts in the abutments, the embankment at the bridge ends shall be made to grade as shown and thoroughly compacted, as provided in the governing specifications, prior to drilling for abutment shafts.

702.8.3.2. Reinforcing Steel. The reinforcing steel cage for the shaft, consisting of longitudinal bars and spiral hooping or lateral ties, shall be completely assembled and placed into the shaft as a unit. Generally, the reinforcing steel unit shall not be placed until immediately before concreting operations are to be started. The longitudinal bars shall be tied to the spiral hooping at intervals not to exceed 12-in. on centers to provide a rigid unit. For cased shafts where the reinforcing steel cage is over 30-ft. in length, the longitudinal bars shall be tied at each intersection of the spiral hooping for a distance of $^1/_5$ the depth of shaft from the bottom of the cage. The cage of reinforcing steel shall be supported from the top by some positive method to prevent slumping downward during extracting of the casing.

In uncased shafts, side spacer blocks of concrete shall be used at intervals along the shaft to insure concentric spacing for the entire length of shaft. In cased shafts, concrete spacer blocks shall not be used, but instead metal “chair” type spacers shall be placed vertically at intervals around the steel cage to insure concentric spacing inside the casing.

702.8.3.3. Concrete. The work shall be performed in accordance with the provisions of Item 702.5. Constructing Concrete Structures, and in conformance with the requirements herein.

Preferably concrete shall be placed immediately after all excavation is complete and reinforcing steel placed.

Concrete placing shall be continuous from the beginning of placement in the shaft or footing bell to the top of shaft or to a construction joint as may be indicated on the plans. Time intervals shall be

allowed for pulling casings, placing forms and other operations necessarily carried on in sequence with the placing operations. The reinforcing steel cage shall be held vertically in some manner to restrain the steel from slumping during the concrete placement operation. Concrete shall be placed through a suitable tube to prevent segregation of concrete materials and unnecessary splashing on the reinforcing steel cage. The tube shall be made in sections to permit the discharge and raising as the placement progresses. A non-jointed pipe may be used if sufficient openings of the proper size are provided to allow for the flow of concrete into the shaft.

Whenever a casing is used, the casing shall be smooth and well-oiled and shall extend sufficiently above the grade of the finished shaft to provide excess concrete to be placed for the anticipated slump due to the casing removal.

Where a casing is to be pulled, the concrete placed in casing shall be of such workability as to require no vibrating or rodding. Where a cap block or ground line strut is shown on the plans to be placed at the top of the drilled shaft, and the cap or strut is shown to be placed monolithic with the drilled shaft, a time interval shall be allowed for placing the required form and reinforcing after any necessary casing removal.

After a placement is completed, the top surface shall be cured and any construction joint area shall be treated as prescribed in Item 702.5. Constructing Concrete Structures.

702.8.4. Test Holes. When shown on the plans, or when ordered by the OWNER in writing, test holes shall be required to establish elevation for "belling" to determine elevation of ground water or to determine other soil characteristics. The diameter and depth of test hole or holes shall be as shown on the plans or as directed by the OWNER.

702.8.5. Test Bells. When shown on the plan, or when ordered by the OWNER in writing, the under-reaming of bells on specified test holes shall be required to establish the ability to under-ream in the soil strata present. The diameter and shape of the test bell shall be as shown on the plans or as directed by the OWNER.

702.8.6. Measurement and Payment. Acceptable drilled shafts in place of the specified diameter shall be measured by the linear foot. At interior bents and piers, shafts shall be measured from 1-ft. below ground for drill shafts at stream crossings, and measured from a point of 6-in. below the ground elevation for grade crossings at the center of shaft unless otherwise indicated on the plans. At street grade separations and at railroad underpasses, the ground elevation shall be the completed roadway section under the structure. At stream crossings and at railroad overpasses, the ground elevation shall be considered as the elevation existing at the time drilling begins. At abutment bents, the length of shaft shall be measured from the bottom of cap elevation.

Footing bells, constructed to the specified dimensions or to the altered dimensions as authorized by the OWNER, shall be measured by the cubic yard of concrete in the acceptable footings placed. The bell shall consist of the authorized footing volume outside the dimensions of the drilled shaft, which for the purpose of measurement shall be considered as extending to the bottom of the bell.

Test holes of the specified diameter shall be measured from the elevation of the ground at the time drilling begins, by the linear foot of acceptable test hole drilled.

Test bells of the specified diameter and shape shall be measured by each test bell acceptably under-reamed.

Drilled shafts shall be paid for at the unit price bid per linear foot of the specified diameter of "drilled shafts," measurements being made as hereinbefore outlined. Where vertical and spiral reinforcing bars from the shaft extend into footings, caps, columns or other concrete members, the cost of such reinforcing shall be included with and paid for as part of "drilled shafts."

Payment shall include the following:

(1) payment for individual completed shaft lengths, up to and including 5-ft. in excess of the maximum plan length shaft as defined herein, shall be made at the unit price bid per linear foot (m) of the specified diameter of "drilled shafts."

(2) payment for that portion of individual completed shaft length in excess of 5-ft. and up to and including 15-ft. more than the maximum plan length shaft as defined herein shall be made at a unit price equal to 115-percent of the unit price bid per linear foot of the specified diameter of "drilled shafts."

(3) payment for individual completed shaft lengths, over 15-ft. in excess of the maximum plan length shafts as defined herein, shall be in accordance with one of the following methods as determined by the OWNER:

(a) Method "A." By unit prices agreed to in writing by the OWNER before said extra work is commenced, subject to all other conditions of the contract.

(b) Method "B." By lump sum price agreed to in writing by the OWNER and the CONTRACTOR before said extra work is commenced, subject to all other conditions of the contract.

Footing bells, constructed to the specified dimensions or to the altered dimensions as authorized by the OWNER, shall be paid for at the contract unit price bid per cubic yard for "bell footing."

Test holes, of the specified diameter, shall be paid for at the contract unit price bid per linear foot for "test hole."

Test bells, of the specified diameter, shall be paid for at the contract unit price for each "test bell."

The foregoing unit prices shall be full compensation for making all excavations; drilling all test holes and test bells; pumping, placing and removing any required casings; furnishing and placing all concrete and reinforcing steel; all backfilling; and furnishing all tools, labor, equipment, materials and incidentals necessary to complete the work. No extra payment shall be made for casings left in place.

702.9. PRECAST AND CAST-IN-PLACE CONCRETE UNITS

702.9.1. Description. This item shall govern the materials used and for constructing, furnishing and placing precast and cast-in-place concrete units at the locations shown and in accordance with the details shown on the plans. Unless otherwise shown on the plans, the CONTRACTOR shall have the option of furnishing cast-in-place, precast (formed) or precast (machine-made) concrete units.

702.9.2. General. Cast-in-place and precast (formed) concrete units shall conform to the requirements of Item 702.2. Concrete Structure Materials, Item 702.3. Mix Design and Mixing Concrete for Structures, Item 702.5. Constructing Concrete Structures, and ASTM Designations C857 Minimum Structural Design Loading for Underground Precast Concrete Utility Structures, and C858 Underground Precast Concrete Utility Structures, as applicable. Concrete units shall be of the various types shown on the plans and designated by letters or numbers to indicate the particular design of each. Each type shall be constructed in accordance with the details shown on the plans or approved by the OWNER, to the depth required by the profiles and schedules given.

702.9.3. Materials.

702.9.3.1. Concrete. Unless otherwise shown on the plans, concrete for cast-in-place and precast formed concrete units shall be Class A or Class PA (as specified by the OWNER) conforming to the requirements of Item 702.3. Mix Design and Mixing Concrete for Structures except that Class C or Class PC concrete (as specified by the OWNER) shall be required when a unit is used with monolithic pipe sewer construction.

Concrete for precast machine-made units shall meet the requirements of ASTM C76 Sections: Reinforced Concrete, Cement, Aggregate, Mixture and Concrete Test Requirements for Concrete and shall have a minimum 28-day compressive strength of 4,000-psi. Vibrating equipment used in making concrete test cylinders must be approved by the OWNER. Testing shall be conducted in accordance with Item 702.3.4.5. Tests.

702.9.3.2. Steel Reinforcement. Steel reinforcement shall conform to the requirements of Item 303.2.9. Steel Reinforcement and the details shown on the plans. A positive means of holding the steel cages in place throughout production of the concrete units shall be provided and shall be subject to approval of the OWNER. Welding of steel reinforcement will not be permitted unless specifically shown on the plan details and shall conform to the requirements of Item 703.3.7. Welding. The maximum variation in the position of the reinforcement shall be plus or minus 10-percent of the wall thickness or plus or minus ½-in., whichever is lesser. In no case, however, shall the cover over the reinforcement be less than shown on the plans.

702.9.4. Forms, Precast Machine-Made Concrete Units. Forms for precast machine-made concrete units shall be made of steel and shall comply with the requirements of Item 702.5.6. Forms.

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

702.9.5. Casting Tolerances. Allowable casting tolerances for concrete units shall not vary more than plus or minus 1/4-in. from the dimensions and configuration shown on the plans. Thickness in excess of that required shall not be cause for rejection, provided that such excess thickness does not interfere with proper jointing or operation as determined by the OWNER.

702.9.6. Marking. The following information shall be clearly marked on each section of precast unit prior to leaving the casting yard.

(1) The date of manufacture.
(2) The name or trademark of the manufacturer.

702.9.7. Storage and Shipment. Precast units shall be stored on level blocking in a manner acceptable to the OWNER. No loads shall be placed on them until design strength is reached. Shipment of acceptable units may be made when the 28-day strength requirements have been met.

702.9.8. Rejection. Precast units may be rejected for nonconformity with any part of these specifications and also for any of the following reasons:

(1) Fractures or cracks passing through the shell, except for a single end crack that does not exceed the depth of the joint.
(2) Surface defects indicating honeycombed or open texture.
(3) Damaged or misshapen ends, where such damage would prevent making a satisfactory joint.

All rejected units shall be so marked by the OWNER and shall be replaced by the CONTRACTOR with acceptable ones meeting the requirements herein. Rejected units shall be removed immediately from the site of work.

702.9.9. Repairs. Occasional imperfections in manufacture or accidental injury during handling may be repaired and will be acceptable if, in the opinion of the OWNER, the repairs are sound, properly finished and cured, and the repaired units conform to the requirements of this specification.

702.9.10. Construction Methods. All excavation shall be in accordance with the requirements of Item 701.2. Structural Removal, Excavation, and Backfill or with excavation in Item 203. Site Preparation.

Precast concrete units shall be bedded on foundations of firm and stable material accurately shaped to conform to their bases.

The CONTRACTOR shall provide adequate means to lift and place the concrete units. Lifting holes may be formed during production, or punched through the fresh concrete immediately after stripping forms; however, care shall be taken not to damage the unit by spalling large areas. All lifting holes shall be repaired in accordance with Item 702.9.9. Repairs.

Connections to new or existing structures shall be made in accordance with details shown on the plans. Jointing material shall be in accordance with Item 501.6. Reinforced Concrete Culvert, Storm Drain, Pipe and Box Section, or as specified in the plans.

Frames, grates, rings and covers, when required by the plans for use in a concrete unit, shall be installed in accordance with Item 806. Metal Materials or Item 502. Appurtenances, as applicable.

702.9.11. Measurement and Payment. Precast and cast-in-place units of each size and type, satisfactorily complete in accordance with the plans and specifications, will be measured by each concrete unit completed to the stage of construction required by the plans.

Excavations and backfill, unless otherwise noted on the plans, will be measured as required by Item 701.2. Structural Removal, Excavation, and Backfill with excavation in Item 203. Site Preparation, or Item 504. Open Cut – Backfill, as appropriate.

Payment for precast concrete units of the types shown on the plans, complete, in place, and in accordance with this specification as measured above, shall be made at the unit bid price for each type

specified. Unless otherwise provided for in the proposal, payment for work performed under this specification shall be full compensation for furnishing, transporting, and placing all concrete, steel reinforcement, brick, mortar, castings for shaping of bed, jointing to new or existing structures, and all other materials, tools, equipment, labor, and incidentals necessary to perform the work prescribed above.

Excavation and backfill, unless otherwise provided in the proposals, shall be paid for as appropriate under Item 701.2. Structural Removal, Excavation, and Backfill with excavation in Item 203. Site Preparation, or Item 504. Open Cut – Backfill.

ITEM 801. BARRIERS, WARNINGS AND DETOUR SIGNS, AND FENCES

801.1. BARRIERS AND WARNING AND DETOUR SIGNS

801.1.1. Description. This item shall consist of the basic requirements which the CONTRACTOR must comply with in order to assure the safety of the public, the OWNER and the CONTRACTOR'S employees. The type and location of signs and barriers shall be provided as required in Item 107.19. Public Convenience and Safety and Item 107.20. Protection Work and of Persons and Property. Additional signs and/or barriers shall be erected if so directed by the OWNER in writing.

801.1.2. General. The amount of street space taken up by construction and maintenance work should be not more than is absolutely necessary, though this does not justify any failure to use such signs, warning devices and channelization as may be required in the roadway for public protection and guidance. The CONTRACTOR shall be held responsible for all damage to the work due to failure of barricades, signs, lights and watchmen to protect it. Whenever evidence is found of such damage, the OWNER may order the damaged portion immediately removed and replaced by the CONTRACTOR at its cost and expense. The CONTRACTOR'S responsibility for the maintenance of barricades, signs and lights and for providing watchmen shall not cease until the project is finally accepted by the OWNER.

801.1.3. Payment. The furnishing, placing and maintaining of barriers, warning devices, detour devices, lights, signs, or other precautionary measures required by law or by the OWNER for the protection of persons or property shall be paid for at the contract unit price for the time they are maintained by the CONTRACTOR until the project is finally accepted by the OWNER.

801.2. METAL BEAM GUARD FENCE

Metal beam guard fence shall conform to TxDOT Item 540. Metal Beam Guard Fence and current version of TxDOT CAD Standard Drawing Metal Beam Guard Fence (MBGF).

801.3. RAILING

801.3.1. Description. This item shall govern for the construction of steel, aluminum, cast iron or pipe railing, including necessary anchorages on bridges, walls or incidental structures as designated on the plans. For concrete railing, refer to TxDOT Item 450.3. Construction, Section B. Concrete Railing.

801.3.2. Materials. All materials shall conform to the requirements of Item 806. Metal Materials.

Railing materials shall be stored above the ground on platforms, skids or other supports. The materials shall be kept free from grease, dirt and contact with dissimilar metals. Care shall be taken at all times to avoid scratching, marring, denting, discoloring or otherwise damaging the railing. Unpacking and storing of rail members, upon arrival at the job site, shall be in accordance with manufacturer's recommendations.

801.3.3. Construction Methods. Railing shall be of size and type shown on the plans and constructed in accordance with details shown on the plans and in conformance with the requirements herein. It shall be constructed to the alignment, grade and camber as designated on the plans. Shop fabricated railing shall be of such uniformity as to insure good joints and continuous lines after erection. Any appreciable amount of cutting, bending or filling required on erection to produce a reasonable fit shall be cause for rejection of the rail. Unless otherwise shown on the plans, rail posts shall be erected plumb, with the top rails parallel to the roadway grade indicated on the plans or to the surface of the structure on which the rail is mounted. The fabrication and erection of metal for railing shall conform to the pertinent provisions of Item 703.3. Steel Structure Construction, and to the requirements of this specification.

Shop drawings shall be prepared and forwarded for approval in accordance with the requirements of Item 703.3. Steel Structure Construction. Splicing of members shall be permitted only as provided by the contract plans.

Splices shall be at rail posts only. All splice locations and details shall be shown on the shop drawings.

The vertical members of the railing may be placed in the correct position and alignment at the time of placing the concrete, or oversize sleeves may be embedded in the proper location and position for subsequent installation of the railing in the sleeves. If sleeves are used, the railing shall be placed in the sleeves and set with molten sulfur compound.

Unless otherwise indicated, aluminum members shall be separated from concrete or steel by a bearing pad conforming to the requirements for preformed rubber fabric pads as described in Item 703.3. Steel Structure Construction. The material shall be ⅛-in. in thickness, unless otherwise specified. All welding shall conform with the recommendations of the American Welding Society. Welding of aluminum material shall be done by an inert gas shielded electric arc welding process in which no flux is used. Torch or flame cutting of aluminum shall not be permitted.

After erection, the railing shall be painted with one prime coat of the type of paint specified on the plans and two field coats of aluminum paint conforming to the requirements of Item 804.2. Painting and Marking. Aluminum railings shall not require field painting. Prior to acceptance, all extrusion marks, grease, dirt and grime shall be cleaned from aluminum railing.

Steel railing shall be given a top coat of the type of paint specified on the plans. This coating shall be of sufficient quality and coverage to protect the metal from corrosion. After erection, the railing shall be cleaned, spot painted and painted in accordance with Item 804.2. Painting and Marking.

If galvanized rail is used, all parts of the rail on which the galvanizing has become scratched, chipped or otherwise damaged shall be thoroughly cleaned painted according to the requirements of Item 804.3.5. Repair of Damaged Zinc Coating. No compensation shall be made for repairing damaged coatings.

Unless otherwise provided, railing shall not be placed until after the false-work for the span has been released. During the construction of railing, care shall be exercised to insure proper functioning of expansion joints, if any.

801.3.4. Measurement and Payment. Railing shall be measured as the number of linear feet of satisfactorily completed railing. Payment shall be made at the contract price bid per linear foot for "railing," which price shall be full compensation for all pipe structural shapes, paint, labor, tools and equipment, and all incidentals necessary for completing the railing in conformity with the plans and these specifications.

801.4. CHAIN LINK FENCE

801.4.1. Description. This item shall consist of one line of chain link fabric supported on posts and constructed as prescribed by this specification at such places as shown on the plans or as designated by the OWNER. The fence overall height and the fabric height shall be as shown on the plans.

801.4.2. Materials. This item covers materials used to construct chain link fencing in accordance with the plans and any typical details which may be shown on the plans. All fence materials furnished shall be in accordance with these specifications, unless otherwise shown on the plans. Failure to meet any of the specifications contained in this section or on the plans shall be cause for rejection and materials shall be replaced at no cost to the OWNER.

801.4.2.1. Chain Link Fencing Fabric. The base metal of the fabric shall be a good commercial quality of steel wire. The wire shall be woven throughout in the form of approximately uniform square mesh, having parallel sides and horizontal and vertical diagonals of approximately uniform dimensions. The top and bottom of the fabric shall be knuckled or barbed as specified. The sizes of wire and mesh shall be as specified. The entire fabric shall be one of the following types:

(1) zinc coated in accordance with ASTM A392 Zinc-Coated Steel Chain-Link Fence Fabric and Item 804.3. Galvanizing;
(2) aluminum coated in accordance with ASTM A491 Standard Specification for Aluminum-Coated Steel Chain-Link Fence Fabric; or
(3) PVC vinyl coated in accordance with ASTM F668 Standard Specification for Poly (Vinyl Chloride) (PVC) and Other Organic Polymer-Coated Steel Chain-Link Fence Fabric and colored in accordance with ASTM F934 Standard Specification for Standard Colors for Polymer-Coated Chain Link Fence Materials.

801.4.2.2. Posts. Posts may be rolled, formed or tubular in cross section and shall be in accordance with ASTM F1043 Strength and Protective Coatings on Metal Industrial Chain Link Fence Framework. All posts shall meet the weight and length requirements as shown on the plans.

801.4.2.3. Rails, Gates, Braces and Fittings. Rails, gates and braces may be rolled, formed or tubular in cross section and shall be in accordance with ASTM F1083 Standard Specification for Pipe, Steel,

Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures. Colored rails, gates, and braces shall be in accordance with ASTM F1043 Strength and Protective Coatings on Metal Industrial Chain Link Fence Framework. Fittings and appurtenances shall be in accordance with ASTM F626 Standard Specification for Fence Fittings.

801.4.2.4. Concrete. Concrete footings shall be Class B or Class PB, as specified by the OWNER, in accordance with Item 702. Concrete Structures.

801.4.3. Construction Methods.

801.4.3.1. General. The chain link fence shall be constructed in accordance with the details on the plans and ASTM F567 Standard Practice for Installation of Chain-Link Fence, and as specified herein, with new materials unless specified otherwise. Chain Link Fence for Tennis Courts shall be constructed in accordance with ASTM F969 Standard Practice for Construction of Chain-Link Tennis Court Fence. Chain link fence for ballfeilds and other sports facilities shall be constructed in accordance with ASTM F2000 Standard Guide for Fences for Ballfields and Other Sports Facilities. All work shall be performed in a workmanlike manner satisfactory to the OWNER. Prior to the beginning of the work, the CONTRACTOR shall locate the position of the work by establishing and marking the line and grade for the fences according to the plans.

801.4.3.2. Clearing Fence Line. The site of the fence shall be sufficiently cleared of obstructions, and surface irregularities shall be graded so that the fence shall conform to the general contour of the ground. The fence line shall be cleared to a minimum width of 2-ft on each side of the centerline of the fence. This cleaning shall consist of the removal of all stumps, brush, rocks, trees or other obstructions which shall interfere with proper construction of the fence. Stumps within the cleared area of the fence line shall be grubbed or excavated.

The bottom of the fence shall be placed a uniform distance above the ground and as specified on the plans. When shown on the plans, or as directed by the OWNER, the existing fences which coincide with or are in a position to interfere with the new fence location shall be removed by the CONTRACTOR as a part of the construction work, unless such removal is listed as a separate item in the bid schedule. All holes remaining after post and stump removal shall be refilled with suitable soil, gravel or other material acceptable to the OWNER and shall be compacted properly with tampers. The work shall include the handling and disposal of all material cleared, excavated or removed, regardless of the type, character, composition or condition of such material encountered.

801.4.3.3. Installing Posts. All posts shall be spaced not more than 10-ft. apart and as shown on the plans. Terminal (end, corner, and pull) posts, gate posts and line posts shall be set in concrete footings of the diameter and depth as shown on the plans. The concrete footings for the posts shall be of sufficient depth to provide a minimum of 2-in. of concrete below the bottom of the posts. The top of the concrete footings shall be slightly above the ground and sloped to drain away from the posts. Holes of full depth and size for the concrete footings for posts shall be dug to the size and depth as shown on the plans. All post settings shall be made carefully so that all posts shall be vertical, in true alignment, centered in the footing, and rigidly secured in position. On terminal (end, corner, and pull) posts and gate posts, the post tops and brace rail clamps around the posts shall be placed before setting the posts in the concrete footings or at such a time that heavy clamps can be installed without spreading them to accommodate the post.

In setting the gate posts, great care must be taken to make sure that gate posts are set apart by the distance shown on the plans. A line drawn across from the top of one gate post to the other must be level regardless of the grade of the groundline. If the ground is not level, the upgrade posts shall be set first to get the proper height for the downgrade gate post. The concrete for post setting shall be allowed to cure for 3-days. Stretcher bar bands and truss bands shall be spread and slipped on end, corner, pull, brace and gate posts as the next operation. Post tops are then inserted on all other posts. Pull posts shall be placed not over 500 ft. apart in straight runs and at each vertical angle point, all as directed by the OWNER. Corner posts shall be placed at each horizontal angle point. Corner and pull posts shall have horizontal braces and truss rods as shown on the plans or as specified. Posts to be

placed in concrete structures shall be placed in previously embedded oversize pipe sleeves and then packed with sulfur compound.

801.4.3.4. Installing Fabric. The fabric shall be placed on the outward facing side of the posts and shall be installed so that the top edge projects over the top rail of the fence. The fabric shall be stretched taut and securely fastened to the post, the top rail and the bottom tension wire. The tension wire shall be installed parallel to the line of the fabric. The bottom of the fabric shall extend to within 2-in. of the natural ground or paved surface. However, over irregular ground, this distance may vary between 1-in. and 6-in. for a distance not to exceed 8-ft. High points of ground shall be excavated to clear the bottom of the fabric; depressions shall be filled and compacted to within 2-in. of the bottom fabric; both shall be considered as incidental work. In locations where chain link fence is installed as a guard or barrier in or on concrete structures such as retaining walls and headwalls, the fabric shall extend to within 6-in. above the concrete surface for structures.

The fabric shall be fastened to end, corner, slope and gate posts with high carbon steel tension bars and steel tension bar bands spaced at 16-in. intervals; and to line posts, top rail and tension wire with tie wires or metal bands. Tie wires or metal bands shall be placed on line posts at intervals of approximately 16-in. and top rail and tension wire at intervals of approximately 24-in.

801.4.3.5. Installing Gates. The widths of any gates to be installed shall be indicated on the plans or in the special provisions.

Gates with fabric 7-ft or more in height shall have a horizontal stiffener. Vertical stiffeners shall be installed at a maximum of 8-ft. centers. A ⅜-in. adjustable tension rod shall be installed on all gates over 4-ft. in width. The corners of gate frames shall be fastened together and reinforced with a fitting designed for the purpose or by welding. All welds shall be ground smooth.

Chain link fence fabric shall be attached to the gate frame by the use of tension bars and tie wires as specified and by suitable tension connectors spaced at approximately 16-in. intervals. The swing gates shall be hung up by at least two (2) steel or malleable iron hinges, so designed as to securely clamp to the gate post and permit the gate to be swung back 180° from the closed position. Gates shall be provided with a combination steel or malleable iron catch and locking attachment of approved design. Stops to hold gates open and a center rest with catch shall be provide where required.

801.4.3.6. Existing Fence Connections. Wherever the new fence joins an existing fence, either at a corner or at the intersection of straight fence lines, a corner post with a brace post shall be set at the junction and braced the same as for corner posts. If the connection is made at other than the corner of the new fence, the last span of the old fence shall contain a brace span.

801.4.3.7. Repair of Damaged Coating. On all galvanized parts where zinc coating has been omitted, chipped off or removed, the steel or iron left exposed shall be repaired. Damaged zinc coating shall be repaired by cleaning and coating according to the requirements of Item 804.3.5. Repair of Damaged Zinc Coating. No compensation shall be made for repairing damaged coatings.

801.4.4. Measurement and Payment. Chain link fence shall be measured in place from center to center of end posts or corner post and shall be the length of fence actually constructed, except the space occupied by the gates. Gates shall be measured in units for each gate installed and accepted.

Payment shall be made at the contract price per linear foot for chain or guard-link fences. This price shall be full compensation for furnishing all material; for all preparation, erection and installation of these materials; and for all labor, equipment, tools and incidentals necessary to complete the work.

Payment shall be made at the contract unit price per each for gates. This price shall be full compensation for furnishing all materials; for all preparation, erection and installation of these materials; and for all labor, equipment, tools and incidentals necessary to complete the work.

Gates measured as provided in this item shall be paid for at the unit price bid for “gate” of the type, height and opening shown on the plans, which price shall be full compensation for furnishing all materials; fabricating; all preparation, hauling, and erection; and for all labor tools, equipment and incidentals necessary for a complete in- place gate installation.

801.5. WIRE FENCE

801.5.1. Description. "Wire fence" shall consist of constructing fence supported on metal or wood posts in accordance with the details and at the locations shown on the plans. The fence shall consist of woven wire fence fabric with or without barbs as specified on the plans.

801.5.2. Materials. This item covers materials used to construct wire fencing in accordance with the plans and any typical details which may be shown on the plans. All materials furnished shall be in accordance with these specifications unless otherwise shown on the plans. Failure to meet all of the specifications contained in this section shall be cause for rejection and materials shall be replaced at no cost to the OWNER.

801.5.2.1. Wire Fencing Fabric. The base metal of the fabric shall be of a good commercial quality of steel or iron as specified. The wire shall be the height and design shown on the plans. The top and bottom wires shall be a minimum No. 10 AWS gauge, and the intermediate wires and vertical stays shall be No. 12½ AWS gauge. The entire fabric shall be zinc coated in accordance with ASTM A116 Zinc-Coated (Galvanized) Steel Woven Wire Fence Fabric and Item 804.3. Galvanizing.

801.5.2.2. Posts.

801.5.2.2.1. Metal. Metal posts may be rolled, formed or tubular in cross section and shall be in accordance with ASTM A702 Standard Specification for Steel Fence Posts and Assemblies, Hot Wrought. All posts shall meet the weight and length requirements as shown on the plans. All posts not galvanized shall be painted with an anti-corrosive paint approved by the OWNER.

801.5.2.2.2. Wood. Wood posts shall be the length and dimensions shown on the plans. The timbers shall be sound and free from all decay, shakes, splits, unsound or excessive knots or any other defects that might impair their strength or durability. Knots shall not exceed one-third of the small dimension or diameter of the post. A line drawn between the center of each end shall not fall outside the center of the post at any point more than by 2-in. Knots shall be trimmed flush and the ends cut square. Untreated posts may be cedar, redwood, cypress or live oak. Treated posts may be pine, spruce or fir. Posts shall be preservative treated according to American Wood-Preservers' Association (AWPA) Standards.

801.5.2.3. Rails, Gates, Braces and Fittings. Rails, gates, and braces may be rolled, formed or tubular in cross section and shall be in accordance with ASTM F669 Strength Requirements of Metal Posts and Rails for Industrial Chain Link Fence. Fittings and appurtenances shall be in accordance with ASTM F626 Fence Fittings. All rails, braces and fittings not galvanized shall be painted with an anti-corrosive paint approved by the OWNER.

801.5.2.4. Barbed Wire. Barbed wire shall be two strand twisted No. 12½ AWS gauge galvanized steel wire with two-point barbs of No. 14 AWS gauge galvanized steel wire and conforming to Class 1 ASTM A121 Metallic Coated Steel Barbed Wire.

801.5.3. Construction Methods. Fence posts shall be spaced at intervals as shown on the plans and set to a minimum depth of 2-ft for wood posts and 2½-ft. for metal posts. Posts shall be set in a vertical position. Corner and pull posts shall be braced in two (2) directions. End and gate posts shall be braced in one (1) direction. Where alignment changes 30° or more, a corner post shall be installed. At alignment angles varying from 15° to less than 30°, the angle post shall be braced to adjacent line posts by diagonal tension wires. Where steel posts are specified, a pull post assembly shall be installed at approximately 500-ft. intervals; where wooden posts are specified, the spacing of pull-post assemblies shall be approximately 1,000-ft. Metal line posts may be driven in place, provided such driving does not damage the posts. Metal corner, end, pull post and braces shall be set in portland cement concrete footings crowned at the top to shed water. All posts shall be placed the minimum depth below ground. Posts shall be set plumb and firm to the line shown on the plans. Backfill shall be thoroughly tamped in 4-in. layers. The timber post braces shall be notched.

The corner, end angle post assembly shall be installed before stretching the wire between the posts. At all grade depressions where stress tends to pull the posts out of the ground, the fencing shall be snubbed or guyed at the critical point by means of a double No. 9-gauge galvanized wire connected to each horizontal line of barbed wire or to the top and bottom wire or wire mesh fabric and to a deadman weighing not less

than 100-lb., buried in the ground. The fencing shall be stretched before being snubbed and guyed. Existing cross fences shall be connected to the new fences and corner posts with braces which shall be placed at junctions with existing fences. The barbed wire and wire fabric shall be drawn taut and fastened to posts with galvanized ties or staples.

801.5.4. Measurement and Payment. Fencing shall be measured by the linear foot of wire fence, measured at the bottom of the fabric along the centerline of the fence from center to center of end posts, excluding gates. Gates shall be measured per each gate, complete in place.

The work performed and material furnished as prescribed by this item, measured as provided in this item, shall be paid for at the unit price bid for "wire fence," which price shall each be full compensation for furnishing and installing all fencing materials (except gates); for all preparation, hauling and installing of same; and for all labor, tools, equipment and incidentals necessary to complete the work, including excavation, backfilling and disposal of surplus material.

Gates measured as provided in this item shall be paid for at the unit price bid for "gate" of the type, height and opening shown on the plans, which price shall be full compensation for furnishing all materials; fabricating; all preparation, hauling and erection; and for all labor, tools, equipment and incidentals necessary for a complete in place gate installation.

ITEM 803. SLOPE AND CHANNEL PROTECTION

803.1. ARTICULATING CONCRETE BLOCK

Articulating concrete blocks or block mattresses may be used for slope protection in wet or dry applications. Cabled articulated concrete block (mattress) shall be used for underwater installations, channels or crossings.

803.1.1. Submittals. Any/all products submitted for use shall include the following:

(1) Product Information Sheet(s) containing product description, statement of intended/ designed use of product and product photographs.

(2) Hydraulic Stability Test Report shall be submitted which complies with the Simon's Li and Associates, Inc. test procedures under Federal Highway Guideline Report FHWA-RD-88-181 or FHWA-RD-89-199.

(3) Suitable samples of the blocks, revetment rope, any required anchoring hardware and geotextile shall be submitted to the OWNER for approval.

(4) Factor of Safety Calculations in accordance with Hydraulic Engineering Circular 23, FHWA HI-97-030 HEC 23, *Bridge Scour and Stream Instability Countermeasures.*

(5) Physical Testing Reports of Sample Submittals

(6) Detail Drawings showing:

- (a) Hardware Anchoring Details (if applicable)
- (b) Typical Cross-sections
- (c) Attachment to Structures (if applicable)
- (d) Product Shop Drawings
- (e) Product Application on Bends (if applicable)
- (f) Anchor Trench Details
- (g) System Articulation (showing achievable contour radius)
- (h) Product's ability to Expand and Contract
- (i) Typical Interlocking Relationship of at least seven (7) Grids in an interlocked matrix.
- (j) Grouted Seam Details (if applicable)

(7) Any other evidence of compliance to the specifications herein and in the plans as deemed necessary by OWNER for approval.

803.1.2. Materials. The Articulating concrete block revetment system shall exhibit a capacity to withstand the specified hydraulic bed shear stress with a Factor of Safety of not less than 1.5.

803.1.2.1. Blocks, General. Manufacturer shall provide data showing manufactured products meet or exceed the specifications.

Individual grids shall consist of a homogeneous mass of consolidated concrete and shall be machine-made by a vibration and compression process composed of approved aggregates with a no-slump concrete mix. The mix water used shall be clean, fresh, free from oil, acids, soluble salts and organic impurities. Cement shall conform to ASTM C150 Portland Cement. Aggregates shall conform to ASTM C33 Concrete Aggregates.

Finished block shall meet the requirements in Table 803.1.2.1.(a) Articulating Concrete Block Requirements.

Table 803.1.2.1.(a) Articulating Concrete Block Requirements

Characteristic	Value	ASTM Designation
Compressive Strength	4000-lbs/in^2 minimum	ASTM C140 Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units
Water Absorption	7% maximum	ASTM C140 (same as above)
Specific Weight	130-lbs/ft^3 minimum	ASTM C140 (same as above)
Freeze-Thaw Durability	<1% / 50 cycles	ASTM C67 Standard Test Methods for Sampling and Testing Brick and Structural Clay Tile

Articulating concrete blocks shall meet the minimum physical characteristics as shown on the plans for the following characteristics.

(1) Total transmissive area percentage defined as system's total open area at base and top of block.
(2) System weight
(3) Minimum Coverage defined as Minimum Coverage for any given block component within the system
(4) Articulation
(5) Block's critical shear value derived from flume testing (lbs/ft^2)

803.1.2.2. Blocks, Non-cabled. The blocks shall be multi-directional, positive, interlocking type and, when installed, the interlocked grid matrix shall exhibit the ability to expand and contract with the underlying terrain.

803.1.2.3. Blocks, Cabled. The individual blocks shall exhibit the ability to physically interlock in two or more horizontal directions without requiring a connection device such as but not limited to: cables, ropes, grids or clips.

Each block shall exhibit one cable tunnel produced in a manner which provides for binding, by use of revetment cables, the blocks into an integrated matrix of grids. When installed, the interlocked grid matrix shall exhibit the ability to expand and contract with the underlying terrain.

803.1.2.4. Prefabricated Mats. Articulating concrete block revetment mats may be fabricated in widths up to 8-ft with lengths up to 40-ft or may be individually placed and post cabled. Special size and shape mats may be fabricated on-site or in-place as needed and as approved by the OWNER.

803.1.2.5. Cable and Fittings. Cable used in the fabrication of articulating concrete block revetment systems shall be made of galvanized steel aircraft cable or polyester, continuous fiber, jacketed cable with a minimum lifting safety factor of 5 to 1. All compression sleeve type fittings used to splice cable ends together shall be made of aluminum. In lieu of compression sleeves, galvanized steel "U" clips may be used.

803.1.2.6. Anchor Hardware. Articulating concrete blocks/mats anchor hardware such as but not limited to Helix Anchors, Duckbill Anchors and Shear Pins shall be specified in the plans and as approved by the OWNER, and any additional anchoring devices (other than cable) shall be of a galvanized steel type.

803.1.2.7. Geotextile (Filter Fabric) Underlayment. Filter fabric shall be a continuous sheet of woven or non-woven geotextile fabric, as selected by the OWNER and shall consist of long chain polymeric filaments, mono-filaments, or yarns such as polypropylene, polyethylene, polyester, polyamide, or polyvinylidene-chloride formed into a stable network such that the filaments or yarns retain relative position to each other.

The geotextile shall be inert to chemicals commonly encountered in natural water and soil conditions. Selection(s) of geotextile shall be made by the OWNER in accordance to a gradation and permeability analysis of the soil and/or fill material on which the grids are to be placed. When woven geotextile is used, the side edges of the panels shall be selvedged or otherwise finished to prevent filaments from pulling away from the edges.

The geotextile shall meet or exceed the minimum requirements in Table 803.1.2.7.(a) Articulated Concrete Block Revetment System Geotextile Requirements.

Table 803.1.2.7.(a) Articulated Concrete Block Revetment System Geotextile Requirements

Characteristic	Value	Standard Test Method
Mullen Burst	* (psi)	ASTM D3786 Hydraulic Bursting Strength of Textile Fabrics-Diaphragm Bursting Strength Tester Method
Trapezoidal Tear	* (lbs)	ASTM D4533 Trapezoid Tearing Strength of Geotextiles
Apparent Opening Size	min 10 sieve number	ASTM D4751 Determining Apparent Opening Size of a Geotextile
Flow Rate	min 70-gal/ft/min	ASTM D4491 Water Permeability of Geotextiles by Permittivity
Permittivity	* (min)	ASTM D4491 Water Permeability of Geotextiles by Permittivity

**These values are to be determined by the Project Engineer*

803.1.3. Articulating Concrete Block Revetment System Construction.

803.1.3.1. Preparation of Surface. All side slope to bed slope radius transitions shall be equal to or greater than the specified block's minimum articulation radius. Areas on which geotextile and articulating concrete blocks are to be placed shall be constructed to the lines and grades shown on the plans. Where such areas are below the allowable grade they shall be brought to grade by placing layers not to exceed 8-in of select material and compacted. The depth of layers and amount of compaction shall be as required to obtain a density equal to the adjoining undisturbed soil, or as specified by the OWNER. All obstructions, such as but not limited to: roots, lumps and projecting stones, shall be removed; and soft or low-density pockets of material shall be removed with the resulting void to be filled with select, compacted material.

The finished sub-grade shall be constructed to exhibit a raked, rolled or otherwise smooth planar profile from a 0-in to +½-in tolerance within a 10-ft straight edge. The subgrade for the cellular concrete blocks shall be free of voids, pits and depressions. Obstructions, such as roots and projecting stones larger than 1-in remaining on the surface, shall be removed. Depressions or areas where obstructions have been removed shall be filled with select material, brought to grade and compacted to plus or minus 3% of a 95% standard proctor density.

Immediately prior to placing the geotextile and cellular blocks, the prepared area shall be inspected by the OWNER and approved before the fabric or blocks are placed thereon.

803.1.3.2. Geotextile Placement. Geotextile shall be placed within the limits shown on the plans. It shall be placed directly on the prepared area. Longitudinal and transverse joints shall be overlapped at least 2-ft. Panels shall be placed so that the upstream strip of fabric will overlap the downstream strip. Securing staples, as needed, shall be inserted though both strips of overlapped fabric along one line through the midpoint of the overlap as needed to temporarily hold panels in place until the subsequent courses of materials can be placed. Each securing staple shall be pushed through the fabric until it bears against the fabric and secures it firmly to the ground. Job site sewing of fabric panels shall be allowed in lieu of overlapping methods as approved by OWNER.

803.1.3.3. Placement of Articulated Concrete Blocks and Mats. Articulating concrete block, revetment blocks, or mats shall be placed within the limits shown on the plans in a manner that produces a level surface.

803.1.3.3.1. Blocks. The Articulating Concrete Blocks shall be placed individually on the geotextile in such a manner as to produce a continually interlocking surface free from field seams and non-interlocked connections, except as approved by the OWNER and/or as shown in the plans. Articulating concrete blocks shall be constructed within the specified lines and grades shown on the plans.

803.1.3.3.2. Mats. Articulating concrete block revetment mats shall be attached to a spreader bar or other approved device and placed on the prescribed area by use of a crane or other approved equipment. The mats shall be placed side by side within a maximum distance of 2-in of each other; any voids greater than 2-in shall be grouted with approved material. When placing mats end to end, a gap of 4-in to 6-in shall be left as to enable connection of mat end loops from one mat to the other (the resulting voids shall be grouted with approved material).

803.1.3.4. Anchoring Articulated Concrete Block and Mat. Articulating concrete block revetment systems shall be anchored according to the plans.

803.1.3.4.1. Trenches. Anchor trenches such as toe trenches, top trenches, upstream termination trenches and downstream termination trenches shall be according to the plans.

803.1.3.4.2. Anchor Hardware. Anchoring devices used in the laboratory testing shall be installed in the field in accordance with the manner in which they were used during the hydraulic stability testing.

803.1.3.5. Finishing Articulating Concrete Blocks and Mats. Articulated concrete blocks that are below the normal waterline and exhibit an average open area greater than 5% shall be backfilled with crushed stone as approved by the OWNER.

Open cell articulating concrete blocks that are above the normal waterline shall be overfilled with material approved by the OWNER to a minimum depth of 35% of the specified block vertical thickness above the grid top surfaces. The surface shall subsequently be hydraulically seeded with a wood fiber mulch and binding agent combination meeting the requirements of Item 204.6.4.4. Hydraulic Mulching acceptable to the OWNER at a rate of 2000- to 2500-lbs./acre with fertilizer and seed added at a rate specified in the plans.

803.2. GABION STRUCTURES

803.2.1. Description. Gabions consist of rectangular, compartmented wire baskets filled with stone used for slope or bank protection and erosion control on open channels. This item shall govern the materials, construction and assembly of gabion structures conforming to the lines, grades, locations and designs as indicated on the plans and specifications, or as established by the OWNER.

803.2.2. Materials. Geotextile, if required, shall be as indicated on the plans. Gabions may be rejected for failure to meet any of the requirements of this specification.

803.2.2.1. Baskets. Gabion baskets shall consist of uniform hexagonal twisted wire mesh or welded wire mesh, coated as specified on the plans. Basket materials shall conform to requirements of ASTM A975 Double-Twisted Hexagonal Mesh Gabions and Revet Mattresses (Metallic-Coated Steel Wire or Metallic-Coated Steel Wire With Poly(Vinyl Chloride) (PVC) Coating), or ASTM A974 Welded Wire Fabric Gabions and Gabion Mattresses (Metallic Coated or Polyvinyl Chloride (PVC) Coated), except as modified by these specifications.

Uniform hexagonal wire mesh shall be woven in double twist pattern with openings fabricated in such a manner as to be nonraveling, or uniform rectangular welded mesh and designed to provide the required flexibility and strength. The perimeter edges of the twisted wire mesh shall be woven around a reinforcing wire in a manner designed to prevent slippage, and the edges of the mesh shall be securely selvedged. All corners shall be reinforced by heavier wire.

Welded wire mesh shall be composed of a series of longitudinal and transverse steel wires arranged substantially at right angles to each other and welded together at the points of intersection by the process of resistance welding to form fabricated sheets with a mesh opening of 3-in. x 3-in.

Gabions shall be so fabricated that the sides, ends, lid, base and diaphragms can be readily assembled at the construction site into rectangular baskets with a minimum thickness of one (1)-ft.

Where the length of the gabion exceeds one-and-one-half times its horizontal width, the gabion shall be divided by diaphragms, of the same mesh and gauge as the body of the gabion, into equal cells whose length does not exceed the horizontal width. Diaphragms shall be secured in the proper position on the base section.

All dimensions for twisted wire mesh gabions are subject to tolerance limit of five-percent.

All dimensions for welded wire mesh gabions are subject to tolerance limit of one-percent.

803.2.2.2. Stone. The stone shall be graded from greater than 3-in. and up to 8-in. in diameter and shall meet the requirements of Item 504.2.2.1. Crushed Stone Embedment. The stone shall have a specific gravity of at least 2.40 and shall have a percent of wear not more than 40 when tested in accordance with TxDOT Test Method TEX-410-A Abrasion of Coarse Aggregate Using the Los Angeles Machine. If required by the OWNER, results of selected tests in accordance with ASTM D5313 Standard Test Method for Evaluation of Durability of Rock for Erosion Control Under Wetting and Drying Conditions shall be provided to the OWNER.

803.2.3. Gabion Construction.

803.2.3.1. Geotextile Filter Layer. If specified on the plans, a geotextile fabric or aggregate filter shall be designed by a registered professional engineer specializing in geotechnical engineering. Geotextile fabric for use as a filter media shall be placed along the gabion structure as shown in the plans. The geotextile fabric shall be placed with a minimum overlap of 18-in. Fabric shall be secured as necessary by pins or other suitable means before placing gabion baskets. Aggregate filter layer shall be constructed as designed.

803.2.3.2. Gabion Basket Assembly. Gabion baskets shall be assembled as instructed by the basket manufacturer or per approved shop drawings.

803.2.3.3. Gabion Basket Placement. Gabion baskets shall be placed in position empty and shall be bound together, each to its neighbor, along all contacting edges in order to form a continuous connecting structural unit. Binding shall be in the same manner as that used to assemble baskets and shall produce a joint that is as strong as the body of the mesh.

Twisted wire mesh gabions 3-ft high that are to be placed in a straight row are to be stretched in the following manner before being tied to the adjacent gabions. Tie together approximately 100-ft of gabion baskets end to end. Secure one end of the row by tying to gabions already filled or fill the end gabion with stone and then stretch baskets sufficiently to remove kinks. While maintaining tension, tie the row of baskets to its neighbor and then fill with stone.

803.2.3.4. Gabion Stone Placement. When the assembled empty gabion baskets have been installed, the gabion stone shall then be placed in the following manner. The gabion baskets may be filled by machine with sufficient additional handwork to accomplish a maximum density and a minimum amount of voids. Vertical outside surfaces shall be placed by hand with select stone in order to achieve the best appearance. Baskets are to be filled in 12-in. layers in order to install a looped inner tie wire in each cell connecting to front and back faces every 12-in. of vertical height in any unsupported face. Individual cells may not be filled more than 1-ft. above any adjacent cell unless looped inner tie wires run in both directions.

803.2.3.5. Gabion Basket Closure.

803.2.3.5.1. Twisted Wire Mesh. Each twisted wire mesh gabion basket shall be filled to its maximum, which is approximately 1½-in. higher than the sides, and the surface leveled with a minimum amount of voids, the lids shall be pried down and over with a bar until the edge of the lid and edge of the basket are together. The heavy projecting wire on the lid shall be twisted around the heavy wire on the sides two complete turns, and the lid shall then be tied to the edges and tops of diaphragms in the same manner as the baskets are assembled so that the finished joint is as strong as the body of the mesh. The lids of the gabion baskets shall also be tied together, each to its neighbor along all connecting edges to insure the formation of a continuous connecting structural unit. Special attention shall be given that all projecting sharp ends of wire are turned in.

803.2.3.5.2. Welded Wire Mesh. Each welded wire mesh gabion basket shall be filled to its maximum height, even with the top and sides and leveled with a minimum amount of voids. The lids shall be closed such that the edges of the lid panel is within 1-in of the top edge of the side front and back panels. The lid shall be connected to these panels using the as instructed by the basket manufacturer or per approved shop drawings.

803.2.4. Gabion Measurement and Payment. Gabions shall be measured for payment either in square yards of the specified minimum thickness or in cubic yards, based on the dimensions shown on the plans or on revised dimensions, where changes are ordered or approved by the OWNER or by ton of material in place. Gabions shall be paid for at the contract unit price complete in place, as provided in the proposal and contract. The contract unit price shall be the total compensation for preparing the subgrade, including excavation; for furnishing, placing and assembling all materials; for furnishing, placing, shaping and tamping backfill; for disposal of all surplus materials; and for all labor, tools, equipment and incidentals necessary to complete the work, all in accordance with the plans and these specifications.

803.3. RIPRAP

803.3.1. Description. This section shall cover work consisting of riprap or reinforced concrete slope protection, all complete in place in conformity with the lines, grades and details shown on the plans and in accordance with these specifications. Riprap shall be used for slope, bank and ditch bottom protection, for erosion control at the ends of pipes and structures, and at other designated locations.

803.3.2. Riprap Materials. Materials used in the performance of the work herein specified shall conform to the requirements of these specifications and as shown on the plans.

803.3.2.1. Geotextiles. If geotextiles are shown in the plans, they shall conform to the requirements of Item 803.4. Geotextiles Used in Drainage and Stabilization Applications unless otherwise specified.

803.3.2.2. Stone.

803.3.2.2.1. Types.

Broken Concrete. The stone used may consist of broken-up concrete removed under contract or obtained from other approved sources. Broken-up concrete shall be as nearly uniform in section as practicable.

Field Stone and Quarry Stone. Natural stone for riprap shall consist of field stone or rough unhewn quarry stone as nearly uniform in section as is practicable. The natural stone shall be dense, resistant to the action of air and water, and suitable in all other respects for the purpose intended.

803.3.2.2.2. Dimensions.

Dry Riprap. Individual material for unmortared riprap shall have a minimum thickness of 4-in. and minimum surface dimensions of 12-in by 24-in. Smaller fragments may be used only to fill the voids between the above minimum size of riprap materials.

Mortared Riprap. Stone for mortared riprap shall be not less than ⅓-cubic-foot in volume and not less than 4-in in length dimensions. The width of the stones shall not be less than twice the thickness.

803.3.2.2.3. Weight.

Dry Riprap, Type A and Type B. Unless otherwise specified, all stones used in these types of riprap shall weigh between 50-lbs and 150-lbs each, and at least 60-percent of the stones shall weigh more than 100-lbs each.

Dry Riprap, Type C and Type D. Fifty-percent of the mass shall be of stones weighing between 100-lbs and 150-lbs each.

Grouted Riprap, Type A and Type B. Stones used in these types of riprap shall weigh between 40-lbs and 150-lbs each.

Grouted Riprap for Foundation Protection. Stones for foundation protection shall range in weight up to 300-lbs each, unless otherwise specified or shown on the plans.

Mortar Riprap. Stones for this purpose shall be fairly large and flat-surfaced. Fifty-percent of the mass shall be of broad flat stones weighing between 100-lbs to 150-lbs each.

803.3.2.3. Concrete, Grout, and Mortar. Materials for concrete, grout and mortar shall conform to the requirements of these specifications. The class of concrete shall be specified on the plans and shall be in accordance with Item 702. Concrete Structures. Mortar and grout required for the several types of riprap shall consist of one part of Portland cement and three parts of sand, thoroughly mixed with water. Mortar shall have a consistency such that it can be handled easily and spread by trowel. Grout shall have a consistency such that it shall flow into and completely fill all joints.

803.3.2.4. Pneumatically Placed Concrete. The strength and design of pneumatically placed concrete riprap shall be specified on the plans as either Type I or Type II in accordance with the Item 702.7. Pneumatically Placed Concrete (Gunite).

803.3.2.5. Reinforcement. Bar reinforcement shall conform to the requirements of the Item 702.9.3.2. Steel Reinforcement. Wire reinforcement shall consist of welded fabric meeting the requirements of ASTM A1064 Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete.

803.3.2.6. Expansion Joint Material. Pre-molded expansion joint material shall conform to the requirements of Item 303.2.12. Joint Filler.

803.3.2.7. Rejection. Materials that fail to meet the requirements of these specifications may be rejected by the OWNER. Such rejection shall incur no cost to the OWNER.

Materials sources from which materials with properties not meeting these specifications are delivered may be rejected as further supply sources to the project by the OWNER. Such rejection shall incur no cost to the OWNER.

803.3.3. Riprap Construction Methods.

803.3.3.1. Surface Preparation, Base Course, and General Construction. Prior to the placing of riprap, the slopes and other areas to be protected with riprap shall be excavated and/or filled, as necessary, compacted and dressed to the line and grade shown on the plans.

The base course or layer of riprap shall be bedded well into the ground with edge-to-edge contact.

Each succeeding course or layer shall be well bedded into and placed on even contact with its preceding course or layer. The finished surface shall present an even, tight surface to line and grades of typical sections.

803.3.3.2. Dry Riprap, Type A and Type B. Dry riprap Type B differs from dry riprap Type A only in that a toe wall of concrete, having dimensions and reinforcement as shown on the plans, shall be used for Type B.

The stones shall be placed in a single layer with close joints. The upright axis of the stones shall make an angle of approximately 90° with the embankment slope. The courses shall be placed from the bottom of the embankment upwardly, the larger stones being placed in the lower courses. Open joints shall be filled with spalls. Stones that project more than the allowable amount in the finished work shall be replaced, embedded deeper or chipped.

803.3.3.3. Dry Riprap, Type C and Type D. Dry riprap Type D differs from dry riprap Type C only in that a toe wall of concrete, having dimensions and reinforcement as shown on the plans, shall be used for Type D.

Stones having one broad flat surface shall be used when possible, this surface being placed on a horizontal earth bed prepared for it and so placed as to overlap the underlying course, the intent being to secure a lapped or "shingled" surface. These stones shall be placed first and roughly arranged in close contact. The spaces between the large stones then shall be filled with stone of suitable size so placed as to leave the surface evenly stepped, conforming to the contour required, and capable of shedding water to the maximum degree practicable.

803.3.3.4. Grouted Riprap, Type A and Type B. The stones shall be placed in the same manner as specified above for Dry Riprap Type A and Type B, with care being taken to prevent earth or sand from filling the spaces between the stones. After the stones are in place, the stones shall be wetted thoroughly and the spaces between the stones shall be completely filled with grout. The surface of the riprap shall be swept with a stiff broom after grouting.

No riprap shall be grouted in freezing weather. The work shall be protected from the sun and kept moist for at least 3-days after grouting. Grouted riprap Type B shall have a concrete toe wall as specified for Dry Riprap Type B.

803.3.3.5. Grouted Riprap for Foundation Protection. Stones for foundation protection shall be graded and so placed as to produce a minimum of voids. The top 6-in shall be of graded smaller stones and shall be grouted, which grout and grouting shall be in conformity with the requirements and methods outlined for Grouted Riprap, Type A and Type B.

803.3.3.6. Mortar Riprap. Stone for this purpose shall be fairly large and flat-surfaced, laid with a true and even surface and a minimum of voids. Broad flat stones shall be placed with the flat surface uppermost and parallel to the slope. The largest stones shall be placed near the base of the slope.

Before placing mortar, the stones shall be wetted thoroughly. As each of the larger stones is placed, it shall be surrounded by fresh mortar, and the adjacent stones shall be shoved into contact. After the larger stones are in place, all of the spaces or openings between them shall be filled with mortar and the smaller stones then placed by shoving them into position, forcing excess mortar to the surface and insuring that each stone is carefully and firmly embedded laterally. All excess mortar forced up shall be spread uniformly to completely fill all surface voids. All surface joints then shall be pointed up roughly either with flush joints or with shallow, smooth-raked joints.

803.3.3.7. Concrete Riprap. Concrete shall be placed in accordance with the details and to the dimensions shown on the plans or as established by the OWNER. Unless otherwise shown by a note on the plans, concrete riprap shall be reinforced using deformed steel bar reinforcement.

Reinforcement shall be properly supported throughout placement of concrete.

Expansion joints shall be placed as shown on the plans.

803.3.3.8. Pneumatically Placed Concrete (Gunite) Riprap Type I and Type II. Pneumatically placed concrete shall be placed in accordance with Item 702.7. Pneumatically Placed Concrete (Gunite) to the dimensions shown on the plans or as established by the OWNER. Reinforcement shall be supported properly throughout placement of concrete. All subgrade surfaces shall be moist when concrete is placed. The surface shall be given a wood float finish or gun finish as directed by the OWNER.

The riprap shall be cured with membrane-curing compound in accordance with Item 702.5.10. Curing Concrete immediately following the finishing operation.

803.3.3.9. Geotextiles. Geotextiles shall be placed and anchored as directed on the plans.

803.3.4. Measurement and Payment. Riprap shall be measured for payment either in square yards of the specified minimum thickness or in cubic yards, based on the dimensions shown on the plans or on revised dimensions, where changes are ordered or approved by the OWNER or by ton of material in place. Riprap shall be paid for at the contract unit price complete in place, as provided in the proposal and contract. The contract unit price shall be the total compensation for preparing the subgrade, including excavation; for furnishing and placing all materials; for furnishing, placing, shaping and tamping backfill; for proper disposal

of all surplus materials; and for all labor, tools, equipment, and incidentals necessary to complete the work, all in accordance with the plans and these specifications.

803.4. GEOTEXTILES USED IN DRAINAGE AND STABILIZATION APPLICATIONS

803.4.1. Geotextile Material Requirements. The geotextile fabric shall be inert to commonly encountered chemicals and hydrocarbons. The fabric shall be packaged, stored and handled in a manner to prevent damage or deterioration which may be caused by moisture, excess sunlight, rodents or other vermin.

The fabric shall conform to the average roll minimum values (lot mean-2 standard deviations), as determined by Federal Highway Administration Task Force 25 guidelines cited below, measured in the weakest direction, as indicated in Table 803.4.1.(a) Geotextile Requirements.

Table 803.4.1.(a) Geotextile Requirements

Designation (Test Method)	Characteristic	Drainage		Stabilization			
		PR[1]	UPR[2]	LOADING			
				Low	Med.	Hi	VHI
ASTM D4632 Grab Breaking Load and Elongation of Geotextiles	Grab Strength (lbs.)	80	180	90	130	180	270
ASTM D4632	Grab Elongation	NA	NA	NA	NA	NA	NA
ASTM D4533 Trapezoid Tearing Strength of Geotextiles	Trapezoidal Tear (lbs.)	25	50	30	40	50	75
ASTM D751 Standard Test Methods for Coated Fabrics	Burst (psi)	130	290	145	210	290	430
ASTM D751	Puncture (psi)	25	80	30	40	75	110

ASTM D4751 Determining Apparent Opening Size of a Geotextile	Apparent Opening Size (AOS) (mm) - soil retention.
For Soils in Which:	AOS:
50% or less passes a #200 mesh sieve	Greater than a #30 sieve
More than 50% passes a #200 mesh sieve	Greater than a #50 sieve

ASTM D4491 Water Permeability of Geotextiles by Permittivity	Permeability (k):
Type of Application:	Required Permeability:
Critical/Severe:	k (fabric) > 10k (soil)
Normal Applications:	k (fabric) > k (soil)

1. PR: Protected Application (used in conjunction with a buffer)
2. UPR: Unprotected Application (used with no protective buffer)

803.4.2. Construction Using Geotextiles. Construction using geotextiles shall be in accordance with the plans, with applicable specifications contained herein Item 803.4. Geotextiles Used in Drainage and Stabilization Applications, or as directed by the OWNER.

803.4.3. Measurement and Payment. If provided as a separate contract item, geotextile shall be measured by the square-yard, complete in place.

Geotextile, when provided as a separate pay item, shall be paid for by the square-yard, complete in place, which price shall include materials, hauling, placing, anchoring, and all other work necessary to achieve a functional geotextile layer in the slope or channel protection. If not provided as a separate contract item, geotextile shall be considered subsidiary to those items provided for slope and channel protection.

ITEM 804. PAINTING AND OTHER PROTECTIVE TREATMENTS; PAVEMENT MARKING

804.1. DESCRIPTION

This item shall govern for the type, quality and application of paint or appropriate coatings or treatments to structures, materials, and pavement surfaces. Such applications include liquid coatings and galvanizing. Items to receive applications may include, but are not limited to, concrete structures, bridges, aerial crossing steel carrier pipes, fences, barriers, concrete pavement, and asphalt pavement. Water tanks and towers are exceptions to these specifications; material specifications and instructions for preparation, cleaning, coating/painting water tanks and towers shall be specified by the OWNER. Painting, coating and other protective treatments shall include, unless otherwise provided in the contract, the preparation and testing of the surfaces; the application, protection and drying of the paint, coating(s) or treatments; the protection of all traffic upon, underneath, or near the structure, material or pavement; the protection of all parts of the structure, material or pavement against disfigurement by any and all painting operations; and the supplying of all tools, tackle, scaffolding, labor, workmanship, paint, coating and/or other materials necessary for the completion of the entire work in accordance with the plans and these specifications.

The intent of the design herein specified is to procure the paints, coatings or treatments in and on structures, materials and surfaces so that the durability and protective value of these designs shall be realized in service. Accordingly, the best quality materials and workmanship are implied throughout. Surface conditions and application requirements are specified with the intent to obtain full adhesion of paint, coatings or treatments to clean, dry, firm surfaces. This shall require careful attention to preparation of surface, to the prevention of contamination and marring of the coating during and after drying, and to uniform, skilled application.

804.2. PAINTING AND MARKING

804.2.1. Safety. Some paints are harmful to the health. All paints shall be handled according to the information contained on the paint safety data sheet. The CONTRACTOR shall be responsible for safety during all cleaning and painting operations.

Unless shown otherwise on the plans, the CONTRACTOR shall be responsible for necessary precautions to contain refuse, dust and paint overspray generated during cleaning and painting operations. Containment shall be such that all falling material is contained and collected for disposal. Noncontainment of airborne particles is permissible provided they are not visible over 100-feet from the actual cleaning or painting operation. A skimmer shall be used when cleaning and painting is over bodies of water. Disposal of collected refuse shall be in accordance with Federal, State and Local rules and regulations.

If spray application is used, workers shall be adequately protected with respirators, and provisions shall be made to prevent infliction of harm upon all other humans and/or animals that might be exposed to the fumes or might eat food upon which the fumes have deposited. This warning shall absolve the OWNER from blame in the event of harm to persons or property from the named cause, and full responsibility for any such harm shall rest upon the CONTRACTOR.

804.2.2. Paint and Marking Materials. All materials used in the painting and marking herein specified shall conform to the material and composition requirements of the applicable TxDOT Material Specification:

DMS-8100 Structural Paints - Formula
DMS-8101 Structural Steel Paints- Performance
DMS-8200 Traffic Paint
DMS-8220 Hot Applied Thermoplastic
DMS-8240, Permanent Prefabricated Pavement Markings
DMS-8241, Temporary Removable, Prefabricated Pavement MarkingsDMS-8242, Temporary Flexible, Reflective Roadway Marker Tabs
DMS-8290, Glass Traffic Beads,

including any official TxDOT amendment or modification of these specifications, where reference to TxDOT or its representatives shall mean the OWNER. The CONTRACTOR shall certify to the OWNER that paint or coatings provided meet TxDOT material requirements.

804.2.2.1. Testing. All paint and paint materials shall be sampled and tested prior to use. All tests shall be conducted in accordance with the methods specified by ASTM or methods set forth in Federal

Standard FED-STD-141C/GEN Paint, Varnish, Lacquer, and Related Materials: Methods of Inspection, Sampling, and Testing. In the absence of any such methods, other suitable methods may be designated and utilized by the OWNER.

804.2.2.2. Rejection. Raw materials and finished products that fail to meet any requirements of these specifications shall be subject to rejection. Final acceptance or rejection shall be based on results of tests on samples of raw materials and finishes as soon as practicable after their arrival at the shipping destination. Approval of materials, as a result of preliminary testing prior to manufacture into finished coatings, shall not be binding upon final approval or rejection. The judgment of the OWNER shall be final in all questions relative to conformance with the provisions of these specifications.

804.2.3. Preparing Structures for Paint.

804.2.3.1. Descaling, Cleaning and Preparation of Surface. Throughout paint application, including shop and field painting, no paint shall be applied over a surface that evidences a loose or scaly condition. Every effort shall be made by means of the most effective and practical methods to remove all loose mill scale, rust, dirt, oil and grease, as well as all other foreign surfaces which would be deleterious to the procurement of the firm paint coating. The original cleaning and preparation of the surface necessarily must be done at the fabricating plant before application of the shop coat, but the same general requirements for painting over a clean, firm surface shall be applicable to all coats.

The OWNER shall look for evidence of faulty surface preparation preceding the shop coat by close inspection of the surface directly prior to application of first field coat, likewise, between first and second field coats. This careful inspection directly in advance of paint application may disclose not only loose, scaly conditions on the surface as a result of faulty preparation but also failure of the paint to harden because of contamination and changes which might have taken place beneath the paint film as a result of rusting and loosening of mill scale after paint has been applied.

The OWNER will test and make determination of the presence of lead or asbestos in the coatings of existing structures. These findings will be addressed via specifications set by the OWNER. Refer to Item 603. Abatement of Coatings Containing Certain Heavy Metals for additional information for information regarding heavy metals.

Therefore, whenever the OWNER has the slightest doubt as to the firm condition of the surface at any time throughout the application of any coats, OWNER shall be expected to explore underneath the surface of any paint coats already applied so as to uncover evidence of infirmity and to direct remedial measures. Any effective methods for removal of rust, scale and dirt, such as through the use of sandblast, hand or rotating metal brushes, scrapers, chisels, hammers or other effective means, shall be acceptable. Undesirable contaminants, which are not allowed to be present on the surface directly prior to paint application and which shall prevent proper hardening and adhesion of the paint film, are grease, oil, oily grime and moisture. Condensed moisture shall be avoided, and other grease-like contaminants shall be removed with solvents, applied with clean rags in such a manner that the oily substance is actually removed and not simply diluted or spread out over a greater area. Particular attention shall be given to the cleaning of fillets, riveted areas, rivet-heads, bolt heads, nuts, washers, drilled or punched holes and welds where loose mill scale, rust, oil and flux are likely to be present.

Unless cleaning is to be done by sandblasting, all weld areas shall be flushed thoroughly with clean water before painting so as to remove any alkaline residue. The flushed surface shall be allowed to thoroughly dry before paint application.

804.2.3.2. Weather Conditions and Dryness of Surface. Paint shall not be applied to any surface where moisture is present and discernible to the eye. Paint shall not be applied at air temperatures below 40°F nor when there is a likelihood of change in weather conditions within 2-hrs after application which would result in air temperatures below 40°F or depositing of moisture in the form of rain. Paint shall not be applied when, in the OWNER'S opinion, impending weather conditions might result in injury to the fresh paint. Weather condition requirements may be waived if the OWNER approves dehumidification or other climate control methods to successfully control the painting environment so as to ensure an equal or improved product.

804.2.3.3. Protecting Surrounding Features. The CONTRACTOR shall protect pedestrian, vehicular and other traffic in the vicinity, and also all portions of the structures not intended to receive paint, against damage or disfigurement by spatters or splashes of paint or paint materials.

804.2.4. Paint Handling and Application.

804.2.4.1. Stirring, Mixing and Care of Paints. All mixed paints shall be made ready for use through reincorporating settled pigment by means of thorough stirring, boxing and straining so that the paint is in its original homogeneous form, free from large agglomerates and skins greater than 9.8-mil in diameter. Paint in mixing pots shall be kept tightly covered when not in use so as to reduce volatile losses and skinning. Paint always shall be in a complete mixed condition when filled into painter's pots, and this filling always shall be through a strainer of 20 mesh cloth or wire or finer. Paint from the painter's pots shall be concentrated into tightly covered mixing pots at the end of the day and shall at no time during application contain skins or large agglomerates, and the interior sides of pots shall be periodically cleaned free of soft skins which might cling to brushes.

804.2.4.2. Thinning. At temperatures above 70°F, all of the paints herein specified for use, when freshly opened from sealed containers and thoroughly stirred, are of normal consistency suitable for good brush application without thinning. At temperatures below 70°F, the consistency may be heavy enough to require some thinning for proper brush application. Adjustments of paint consistency shall be accomplished by heating in hot water or on steam radiators. Adjustments of paint consistency by thinning so as to meet any and all conditions shall be done only at the discretion of the OWNER and with the OWNER's specific permission. The general rule which shall be applied for thinning paints shall be that the full hiding coat can be applied so as to thoroughly obscure the surface being painted, whether bare metal or undercoat, without sags and runs. Proper use of paints should remove the necessity for thinning because of evaporated volatiles as a result of allowing the paints to stand in uncovered containers.

804.2.4.3. Brush Application. Painting shall be done by workers skilled in the craft of structural metal painting. Good workmanship by skilled workers is evidenced by the following outstanding features: all crevices, sharp angles, etc., are first traced; the entire surface is then coated without attempt to "layoff" the paint in one direction; lastly, runs from crevices are picked up and the paint is laid off in one direction so as to leave a uniform film free from runs, sags or brush marks caused by not "feathering" or blending one lap into another. Brushes preferably shall be round or oval in shape, but if flat brushes are used, they shall not exceed 4-in in width; brushes should be springy and not flabby. Brushes shall not be permitted to become seedy from skins.

804.2.4.4. Spray Application. The equipment used for spray painting shall meet the approval of the OWNER and shall have adequate provisions for separation of moisture from the air stream in contact with the paint. Before thinning for spray application is permitted by the OWNER, at least 50-psi air pressure shall be present at the gun, the gun is not clogged with dried or semi-dried paint, and the spray gun is adequate for the work and has a proper spray head for application of paints used. A spray gun correctly held is approximately 8-in from and always perpendicular to the surface being painted. The painter shall steadily move the gun through a deliberate pattern that permits overlapping of the previous pass by 50-percent and at a speed that shall produce a full uniform coat. Over spray shall be held at a minimum.

804.2.5. Painting New Structures.

804.2.5.1. Number of Coats and Color. Except for surfaces specified herein or otherwise provided for on the plans, all structural steel shall be painted with one (1) shop coat of primer, one (1) field coat primer and two (2) field coats of paint as specified on plans. The paint shall be omitted from the surface of structural steel which shall be in contact with concrete in the finished structure. At the time concrete is placed, such surfaces of structural steel shall be free from dirt, scale, rust, paint, oil or other foreign material.

804.2.5.2. Shop Coat. It shall be mandatory to apply the shop coat by brushing or rolling, unless the surfaces to be painted are cleaned by sandblasting, in which case spray application of the shop coat shall be permitted. When all fabrication work is completed and has been tentatively accepted as such,

all surfaces not painted before assembling shall be cleaned as provided in Item 804.2.3.1. Descaling, Cleaning and Preparation of Surface and painted with one coat of primer. Pieces shall not be loaded for shipment until thoroughly dry. No painting shall be done after loading material on cars. Erection marks for the field identification of members shall be painted on previously painted surfaces. The top of the top flange of stringers shall not be painted. Machine finished surfaces shall be coated as soon as practicable after being accepted.

Surfaces of iron and steel castings milled for the purpose of removing scale, scabs, fins, blisters or other surface deformations shall generally be given the shop coat of paint.

All metal surfaces which shall be within 2-in of field welds shall be coated with linseed oil in advance of the application of shop coat paint and left bare of paint until field welding has been completed. The shop coat shall be applied as uniformly as possible by brushing with the intent of securing an average wet film thickness of 3.5-mils or 468-sq.ft.-of-surface-per-gallon of paint. The corresponding dry film thickness shall be 2.1-mils.

Portions of structures entailing difficult application of the field coats after erection may be completely painted before assembling or erection at the discretion of the OWNER.

804.2.5.3. Field Cleaning and Spot Painting. When the erection work is complete, including straightening of bent metal, etc., the shop-coated surface shall be restored to a serviceable condition acceptable to the OWNER by means of preparation of surface as outlined in Item 804.2.3.1. Descaling, Cleaning and Preparation of Surface and smoothing and touching up marred places in the shop coat film with primer. Field welds, heads of field rivets and bolts and any other surfaces to be painted which have not yet been shop coated shall be painted with primer.

The coating of linseed oil specified in Item 804.2.5.2. Shop Coat shall be thoroughly removed, as directed for removal of grease and oil in Item 804.2.3.1. Descaling, Cleaning and Preparation of Surface, immediately prior to erection.

804.2.5.4. First Field Coat. When field cleaning and restoration of shop coat has been completed and all shop coat is thoroughly dry, the first field coat of primer may be applied. Finished surfaces intended for sliding contact shall be given a coat of approved graphite grease immediately prior to being placed in the structure. Graphite grease shall be composed of dry graphite flakes mixed with sufficient light grease or heavy oil so as to form a thick paste suitable for the purpose. Field coats shall not be required on the bottom surface of shoe castings or bearing plates in direct contact with concrete nor on the top surfaces of beams, girders, etc. on which a concrete slab is to be placed in direct contact. The first field coat shall be applied as uniformly as possible, either by spraying, rolling, brushing, or a combination of these with the intent of securing an average wet film thickness of 3.5-mils.

804.2.5.5. Finish Coats. When the first field coat, including all touched-up marred places, has thoroughly hardened, the finishing field coats of finish paint may be applied. Cracks and cavities which have not been sealed in a watertight manner by the first field coat shall be suitably corrected. This correction shall be allowed to sufficiently surface dry before the second field coat is applied so as not to work up into finish paint. After application of the finishing field coat, the painted portion of the structure shall present a uniform color and appearance throughout.

The finish paint coat shall be applied as uniformly as possible by spraying, rolling, or brushing, with the intent of securing an average dry film thickness of 1.5-mils for each coat of paint applied.

804.2.6. Cleaning and Painting Existing Structures. All structures to be painted shall be cleaned thoroughly in accordance with Item 804.2.3.1. Descaling, Cleaning and Preparation of Surface to prepare the surfaces to receive new paint. Rust spots shall be cleaned to bare metal. Structures shall be spot painted with primer in accordance with Item 804.2.5.3. Field Cleaning and Spot Painting prior to application of paint to the entire surface unless otherwise specified. After the cleaning and spot-paint have dried thoroughly, the application of two (2) field coats of paint shall be applied. The application of paints shall conform to the pertinent articles of this specification.

804.2.7. Removal of Paint Improperly Applied. All paint which has been improperly applied and fails to dry and harden properly, or to adhere tightly to underlying metal or other paint film, or does not evidence a normal, workmanlike appearance in conformance with the intent of these specifications, shall be remedied or

thoroughly removed and replaced at the expense of the CONTRACTOR. When the final field coat does not have a uniform color and appearance throughout the structure, it shall be corrected by the use of whatever additional coats are necessary. Removal of freshly applied paint which has not yet set shall be effected with the use of appropriate solvents. Removal of dried paint films shall be effected either by means of sandblasting or scraping, meeting the approval of the OWNER.

804.2.8. Cleaning and Marking Pavements. When the CONTRACTOR is responsible for marking pavements, as identified in the plans, cleaning and marking shall conform to these specifications and the Texas Manual on Uniform Traffic Control Devices.

Markings shall be applied only when the pavement surface is dry and clean, which may be accomplished with machinery specialized to prepare pavement in front of the marking operation. The CONTRACTOR shall be comply with all environmental condition restrictions recommended by the manufacturer of pavement paints or other markings. Glass beads or other refractive material and application rates shall be as identified on the plans.

Temporary markings shall be thoroughly removed to the satisfaction of the OWNER using an approved method prior to the application of permanent markings.

804.3. GALVANIZING

804.3.1. General. Zinc used for galvanizing shall be grade Prime Western conforming to ASTM B6 Zinc (Slab Zinc). Except as otherwise specified, materials shall be galvanized by the hot-dip or electro-depositing process.

804.3.2. Coating Requirements. The minimum weight of coating and other requirements shall be as shown in Table 804.3.2.(a) Galvanizing Minimum Weight. The weight shown is ounces per square foot of the surface area. All surfaces, when tested separately, shall meet the minimum requirement.

804.3.3. Workmanship. The zinc coating shall adhere tenaciously to the surface of the base metal. The finished product shall be free from blisters and excess zinc, and the coating shall be even, smooth and uniform throughout. Machine work, die work, cutting, punching, bending, welding, drilling, thread cutting, straightening and other fabricating shall be done as far as is practicable before the galvanizing. All members, nuts, bolts, washers, etc. shall be galvanized before a structural unit is assembled. All uncoated spots or damaged coatings shall be cause for rejection.

Products that are warped or distorted to the extent of impairment for the use intended shall be rejected.

804.3.4. Testing. Test coupons for determining the quantity and quality of galvanizing shall be of such size and shall be wired to the materials to be galvanized before immersion so as to represent the amount of coating deposited on the finished product.

The weight of coating shall be determined in accordance with ASTM A90 Test Method for Weight [Mass] of Coating on Iron and Steel Articles with Zinc or Zinc-Alloy Coatings, modified to determine the coating of each surface separately.

Nondestructive tests for uniformity of coating may be made by the OWNER with a magnetic instrument in accordance with ASTM E376 Standard Practice for Measuring Coating Thickness by Magnetic-Field or Eddy-Current (Electromagnetic) Test Methods.

Table 804.3.2.(a) Galvanizing Minimum Weight

Material	ASTM Designation	Min. Weight of Coating oz./sq.ft.
Steel product including structural shapes, tie rods, handrails, and miscellaneous items	A123, Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products	2.00
Hardware including casting, rolled, pressed, and forged articles	A153, Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware	2.00
Bolts, screws, nuts, and washers	A153 Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware	1.25
Chain link fence fabric (galvanized after fabrication)	A392, Standard Specification for Zinc-Coated Steel Chain-Link Fence Fabric	1.20
Chain link fence fittings & accessories	F626 Standard Specification for Fence Fittings	1.20
Chain link fence post, gates, rails, and braces	F1083 Standard Specification for Pipe, Steel, Hot-Dipped Zinc-Coated (Galvanized) Welded, for Fence Structures	1.80
CMP culverts and underdrains	A929 Standard Specification for Steel Sheet, Metallic-Coated by the Hot-Dip Process for Corrugated Steel Pipe	1.00
Steel pipe	A53 Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless	1.80
Iron or steel wire fencing	A116, Standard Specification for Metallic-Coated, Steel Woven Wire Fence Fabric	0.80
Steel or iron sheets	A653 Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process	0.63
Barbed wire	A121 Standard Specification for Metallic-Coated Carbon Steel Barbed Wire	0.80
Electrolier standards, 7-gauge steel and over	A123 Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products	2.00
Electrolier standards, under 7-gauge steel	A123 Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products	1.50

804.3.5. Repair of Damaged Zinc Coating. Zinc coating, which has been field or shop cut, burned by welding, abraded, or otherwise damaged to such extent as to expose the base metal, shall be repaired and recoated by one of the following methods:

804.3.5.1. Hot-Dip Process. The damaged areas shall be thoroughly stripped and cleaned, and a coating of zinc shall then be applied by the hot-dip process.

804.3.5.2. Metalizing Process. The damaged area shall be thoroughly cleaned by blasting with sharp sand or steel grit. The blasted area shall lap the undamaged zinc coating at least ½-in.

Zinc wire containing not less than 99.98-percent zinc shall be used in the metalizing operation. A zinc coating shall be applied to the damaged area with a metalizing gun to a thickness of not less than 0.005-in. on the damaged area and shall taper to zero thickness at the edge of the blasted undamaged section.

804.3.5.3. Zinc Rich Paint. The damaged area shall be thoroughly cleaned by wire brushing and all traces of welding flux and loose or cracked zinc coating removed prior to painting. The cleaned area shall be painted with two coats of zinc oxide-zinc dust paint. The coating thickness shall be 50-percent

greater than the surrounding coating thickness, but not more than 4.0-mils. Zinc-rich paints shall be based on organic binders, premixed and formulated specifically for use on steel surfaces and shall provide a dried film containing a minimum of 92-percent zinc dust, by weight.

804.3.6. Rejection. Raw materials and finished products that fail to meet any requirements of these specifications shall be subject to rejection. Final acceptance or rejection shall be based on results of tests on samples of raw materials and finishes as soon as practicable after their arrival at the shipping destination. Approval of materials, as a result of preliminary testing prior to manufacture into finished coatings, shall not be binding upon final approval or rejection. The judgment of the OWNER shall be final in all questions relative to conformance with the provisions of these specifications.

804.4. MEASUREMENT AND PAYMENT

Unless otherwise provided in the plans and special provisions, painting, coating, marking, or other treatments such as galvanizing shall not be measured for payment, nor shall payment be made as a separate contract item. The cost thereof shall be included in the contract pay items as are provided for the item to be painted, treated or marked, which prices shall be the total compensation for cleaning, spot painting or treatment, application of paint, coating, marking or treatment, and for furnishing all labor, equipment, material, scaffolding, protection of traffic, tools and incidentals necessary to complete the work, all in accordance with the plans and these specifications.

804.5. SPECIALTY COATINGS

Manufacturer's specifications shall be followed when applying specialty coatings, such as shown in the contract documents.

Item 100
Preparing Right of Way

1. DESCRIPTION

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

2. CONSTRUCTION

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

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

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

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

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

3. MEASUREMENT

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

4. PAYMENT

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

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

Item 104
Removing Concrete

1. DESCRIPTION

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

2. CONSTRUCTION

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

3. MEASUREMENT

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

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

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

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

4. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for “Removing Concrete” of the type specified. This price is full compensation for breaking the concrete; loading, hauling, and salvaging or disposing of the material; and equipment, labor, tools, and incidentals.

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

Item 105

Removing Treated and Untreated Base and Asphalt Pavement

1. DESCRIPTION

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

2. CONSTRUCTION

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

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

3. MEASUREMENT

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

4. PAYMENT

The work performed in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for “Removing Treated and Untreated Base and Asphalt Pavement” of the depth specified. This price is full compensation for breaking the material, loading, hauling, unloading, stockpiling or disposing; repair to areas outside designated locations for removal; and equipment, labor, tools, and incidentals.

Item 110
Excavation

1. DESCRIPTION

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

2. CONSTRUCTION

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

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

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

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

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

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

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

3. MEASUREMENT

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

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

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

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

4. PAYMENT

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

authorized excavation; drying; undercutting subgrade and reworking or replacing the undercut material in rock cuts; hauling; disposal of material not used elsewhere on the project; scarification and compaction; and equipment, labor, materials, tools, and incidentals.

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

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

Item 132
Embankment

1. DESCRIPTION

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

2. MATERIALS

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

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

Table 1
Testing Requirements

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

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

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

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

3. CONSTRUCTION

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

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

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

Construct embankments to the grade and sections shown on the plans. Construct the embankment in layers approximately parallel to the finished grade for the full width of the individual roadway cross-sections unless otherwise shown on the plans. Ensure that each section of the embankment conforms to the detailed sections or slopes. Maintain the finished section, density, and grade until the project is accepted.

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

Treat material in accordance with Item 260, "Lime Treatment (Road-Mixed)" or Item 275, "Cement Treatment (Road-Mixed)" when required. Obtain approval to incorporate rock and broken concrete produced by the construction project in the lower layers of the embankment. Place the rock and concrete outside the limits of the completed roadbed when the size of approved rock or broken concrete exceeds the layer thickness requirements in Section 132.3.4., "Compaction Methods." Cut and remove all exposed reinforcing steel from the broken concrete.

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

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

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

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

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

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

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

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

3.4.1. Ordinary Compaction. Use approved rolling equipment complying with Item 210, "Rolling," to compact each layer. Use specific equipment when required by the plans or the Engineer. Do not allow the loose depth of any layer to exceed 8 in., unless otherwise approved. Bring each layer to the moisture content directed

before and during rolling operations. Compact each layer until there is no evidence of further consolidation. Maintain a level layer to ensure uniform compaction. Recompact and refinish the subgrade at no additional expense to the Department if the required stability or finish is lost for any reason.

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

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

Table 2
Field Density Control Requirements

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

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

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

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

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

3.6. Acceptance Criteria.

3.6.1. Grade Tolerances.

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

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

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

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

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

4. MEASUREMENT

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

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

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

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

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

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

Measurement of retaining wall backfill in embankment areas is paid for as embankment unless otherwise shown on the plans. Limits of measurement for embankment in retaining wall areas are shown on the plans.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Embankment (Final)," "Embankment (Original)," or "Embankment (Vehicle)" of the compaction method and type specified. This price is full compensation for furnishing embankment; hauling; placing, compacting, finishing, and reworking; disposal of waste material; and equipment, labor, tools, and incidentals.

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

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

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

Item 134
Backfilling Pavement Edges

1. DESCRIPTION

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

2. MATERIALS

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

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

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

2.1.3. **Type C**. Mulch sodding backfill secured from an approved source in accordance with Section 162.2.2., "Mulch Sod."

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

2.3. **Fertilizer**. Furnish fertilizer in accordance with Article 166.2., "Materials," if specified on the plans.

2.4. **Water**. Furnish water required for proper compaction, promotion of plant growth, or emulsion dilution in accordance with Article 168.2., "Materials."

3. CONSTRUCTION

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

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

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

3.3. **Fertilizer**. Distribute fertilizer uniformly in accordance with Article 166.3., "Construction," after final finishing of the backfill material when fertilizer is specified on the plans. Moisten to a depth of 4 in. or to the maximum depth of the backfill, whichever is less, after applying fertilizer.

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

4. MEASUREMENT

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

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Backfill" of the type specified. This price is full compensation for furnishing the emulsified asphalt, water, fertilizer, and backfill material; and for equipment, labor, materials, tools, and incidentals.

Item 150
Blading

1. DESCRIPTION

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

2. EQUIPMENT

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

3. CONSTRUCTION

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

4. MEASUREMENT

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

5. PAYMENT

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

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

Item 152
Road Grader Work

1. DESCRIPTION

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

2. EQUIPMENT

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

3. CONSTRUCTION

Remove or rework unsuitable or unstable materials in accordance with Article 110.2., "Construction," or as directed. Grade the roadway and shape to the typical sections shown on the plans. Finish to a profile uniform and consistent with the topography. Scarify existing natural ground or roadbed and compact in accordance with the method shown on the plans and as outlined in Article 132.3., "Construction." Supplement "Road Grader Work" with Item 154, "Scraper Work," Item 156, "Bulldozer Work," or both when shown on the plans. Perform work in accordance with the requirements of the governing Item.

4. MEASUREMENT

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

5. PAYMENT

The work performed in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Road Grader Work (Ordinary Compaction)" or "Road Grader Work (Density Control)." This price is full compensation for furnishing and operating equipment and for labor, materials, tools, and incidentals.

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

Item 156
Bulldozer Work

1. DESCRIPTION

Excavate, remove, use, or dispose of materials with a bulldozer. Construct, shape, and finish earthwork in conformity with the required lines, grades, and typical cross-sections as shown on the plans, or as directed.

2. EQUIPMENT

Use a tractor, crawler, or rubber tired type with a blade attachment at least 8 ft. long. Use a scarifier or ripper with the required tractor when necessary. Use equipment of the type specified on the plans, meeting the following requirements:

2.1. Type A. Manufacturer's rated net flywheel power of less than 150 horsepower based on SAE standard J1349.

2.2. Type B. Manufacturer's rated net flywheel power of 150 or greater horsepower based on SAE standard J1349.

3. CONSTRUCTION

Perform bulldozer work on the areas as specified on the plans, utilizing equipment as specified above. Rough in with bulldozer work where plans designate "Bulldozer Work" and "Blading," or "Road Grader Work," within the same limits. Finish in accordance with specifications for "Blading" or "Road Grader Work." Compact embankment to ordinary compaction in accordance with Item 132, "Embankment," unless otherwise shown on the plans.

4. MEASUREMENT

This Item will be measured by the actual number of hours of use of the specified type of equipment operated.

5. PAYMENT

The work performed in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Bulldozer Work." This price is full compensation for furnishing and operating equipment, labor, materials, tools, and incidentals. "Sprinkling" and "Rolling" will not be paid for directly but will be subsidiary to this Item. Work performed under this Item will not include work specified for payment under other Items.

Item 158
Specialized Excavation Work

1. DESCRIPTION

Excavate, remove, use, or dispose of materials for erosion control or other specialized needs. Construct, shape, and rough in earthwork in conformance with the required lines, grades, and typical sections as shown on the plans, or as directed.

2. EQUIPMENT

Use equipment of the type specified on the plans unless otherwise approved. Use equipment that is able to consistently and efficiently produce the desired results.

2.1. Dragline. Self-propelled dragline with a minimum 1/2-cu. yd. bucket.

2.2. Backhoe. Tractor-mounted backhoe capable of excavating a trench at least 12 in. wide in one pass.

2.3. Hydraulic Excavator. Hydraulic excavator with a retractable, telescoping, rotatable boom attached to an interchangeable excavating or grading bucket at least 36 in. wide. The entire excavating mechanism must be mounted on a platform that rotates on a turntable assembly.

2.4. Front-End Loader. Tractor-mounted front-end loader with a minimum bucket capacity of 1-1/4 cu. yd.

3. CONSTRUCTION

Perform "Specialized Excavation Work" on the areas shown on the plans or as directed. Use suitable excavated materials, including topsoil, for constructing the required roadway sections. Compact material placed in embankment to ordinary compaction in accordance with Article 132.3., "Construction," unless otherwise shown on the plans. Accept ownership of all excavated material unless otherwise shown on the plans. Stockpile materials designated salvageable at designated sites. Properly dispose of excess excavated material in accordance with local, state, and federal requirements at locations outside the right of way.

4. MEASUREMENT

This Item will be measured by the hour of work performed for specified equipment or by the cubic yard. Measurement by the cubic yard will be further defined as follows:

4.1. Original. The cubic yard will be measured in its original position as computed by the method of average end areas.

4.2. Vehicle. The cubic yard will be measured in vehicles at the point of excavation.

5. PAYMENT

The work performed in accordance with this Item and measured by the hour as provided under "Measurement" will be paid for at the unit price bid for "Specialized Excavation Work" of the equipment type specified or; for cubic yard measurement, payment will be made at the unit price bid for "Specialized Excavation Work (Original)," or "Specialized Excavation Work (Vehicle)." This price is full compensation for hauling and disposing or stockpiling of excess materials and for equipment, labor, materials, tools, and incidentals. "Sprinkling" and "Rolling" will not be paid for directly but will be subsidiary to this Item.

Item 164
Seeding for Erosion Control

1. DESCRIPTION

Provide and install temporary or permanent seeding for erosion control as shown on the plans or as directed.

2. MATERIALS

2.1. **Seed.** Provide seed from the previous season's crop meeting the requirements of the Texas Seed Law, including the testing and labeling for pure live seed (PLS = Purity × Germination). Furnish seed of the designated species, in labeled unopened bags or containers to the Engineer before planting. Use within 12 mo. from the date of the analysis. When Buffalograss is specified, use seed that is treated with KNO_3 (potassium nitrate) to overcome dormancy.

Use Tables 1–4 to determine the appropriate seed mix and rates as specified on the plans. If a plant species is not available by the producers, the other plant species in the recommended seed mixture will be increased proportionally by the PLS/acre of the missing plant species.

Table 1
Permanent Rural Seed Mix

District and Planting Dates	Clay Soils Species and Rates (lb. PLS/acre)		Sandy Soils Species and Rates (lb. PLS/acre)	
1 (Paris) Feb. 1–May 15	Green Sprangletop Sideoats Grama (Haskell) Bermudagrass Little Bluestem (Native) Illinois Bundleflower	0.3 3.2 1.8 1.7 1.0	Green Sprangletop Bermudagrass Bahiagrass (Pensacola) Sand Lovegrass Weeping Lovegrass (Ermelo) Partridge Pea	0.3 1.5 6.0 0.6 0.8 1.0
2 (Ft. Worth) Feb. 1–May 15	Green Sprangletop (Van Horn) Sideoats Grama (Haskell) Texas Grama (Atascosa) Hairy Grama (Chaparral) Shortspike Windmillgrass (Welder) Little Bluestem (OK Select) Purple Prairie Clover (Cuero) Engelmann Daisy (Eldorado) Illinois Bundleflower Awnless Bushsunflower (Plateau)	1.0 1.0 1.0 0.4 0.2 0.8 0.6 0.75 1.3 0.2	Green Sprangletop (Van Horn) Hooded Windmillgrass (Mariah) Shortspike Windmillgrass (Welder) Hairy Grama (Chaparral) Slender Grama (Dilley) Sand Lovegrass (Mason) Sand Dropseed (Borden County) Partridge Pea (Comanche) Little Bluestem (OK Select) Englemann Daisy (Eldorado) Purple Prairie Clover	1.0 0.2 0.2 0.4 1.0 0.2 0.2 0.6 0.8 0.75 0.3
3 (Wichita Falls) Feb. 1–May 15	Green Sprangletop (Van Horn) Sideoats Grama (Haskell) Texas Grama (Atascosa) Hairy Grama (Chaparral) Shortspike Windmillgrass (Welder) Little Bluestem (OK Select) Blue Grama (Hachita) Western Wheatgrass (Barton) Galleta Grass (Viva) Engelmann Daisy (Eldorado) Awnless Bushsunflower (Plateau)	0.6 1.0 1.0 0.4 0.2 0.8 0.4 1.2 0.6 0.75 0.2	Green Sprangletop (Van Horn) Hooded Windmillgrass (Mariah) Shortspike Windmillgrass (Welder) Hairy Grama (Chaparral) Sand Lovegrass (Mason) Sand Dropseed (Borden County) Partridge Pea (Comanche) Little Bluestem (OK Select) Englemann Daisy (Eldorado) Purple Prairie Clover (Cuero)	1.0 0.2 0.2 0.4 0.2 0.2 0.6 0.8 0.75 0.3
4 (Amarillo) Feb. 15–May 15	Green Sprangletop Sideoats Grama (Haskell) Blue Grama (Hachita) Buffalograss (Texoka) Illinois Bundleflower	0.3 3.6 1.2 1.6 1.0	Green Sprangletop Weeping Lovegrass (Ermelo) Blue Grama (Hachita) Sand Dropseed (Borden Co.) Sand Bluestem Purple Prairie Clover	0.3 0.8 1.0 0.3 1.8 0.5

Table 1 (continued)

Permanent Rural Seed Mix

District and Planting Dates	Clay Soils Species and Rates (lb. PLS/acre)		Sandy Soils Species and Rates (lb. PLS/acre)	
5 (Lubbock) Feb. 15–May 15	Green Sprangletop Sideoats Grama (El Reno) Blue Grama (Hachita) Buffalograss (Texoka) Illinois Bundleflower	0.3 3.6 1.2 1.6 1.0	Green Sprangletop Weeping Lovegrass (Ermelo) Blue Grama (Hachita) Sand Dropseed (Borden Co.) Sand Bluestem Purple Prairie Clover	0.3 0.8 1.0 0.3 1.8 0.5
6 (Odessa) Feb. 1–May 15	Green Sprangletop (Van Horn) Sideoats Grama (South Texas) Blue Grama (Hachita) Galleta Grass (Viva) Shortspike Windmillgrass (Welder) Pink Pappusgrass (Maverick) Alkali Sacaton (Saltalk) Plains Bristlegrass (Catarina Blend) False Rhodes Grass (Kinney) Whiplash Pappusgrass (Webb) Arizona Cottontop (La Salle)	1.0 1.0 0.4 0.6 0.2 0.6 0.2 0.2 0.1 0.6 0.2	Green Sprangletop (Van Horn) Hooded Windmillgrass (Mariah) Blue Grama (Hachita) Hairy Grama (Chaparral) Sand Lovegrass (Mason) Sand Dropseed (Borden County) Indian Ricegrass (Rim Rock) Sand Bluestem (Cottle County) Little Bluestem (Pastura) Purple Prairie Clover (Cuero)	1.0 0.2 0.4 0.4 0.2 0.2 1.6 1.2 0.8 0.3
7 (San Angelo) Feb. 1–May 1	Green Sprangletop (Van Horn) Sideoats Grama (Haskell) Texas Grama (Atascosa) Hairy Grama (Chaparral) Shortspike Windmillgrass (Welder) Little Bluestem (OK Select) Blue Grama (Hachita) Western Wheatgrass (Barton) Galleta Grass (Viva) Engelmann Daisy (Eldorado) Illinois Bundleflower (Sabine)	1.0 1.0 1.0 0.4 0.2 0.4 0.4 1.2 0.6 0.75 1.0	Green Sprangletop (Van Horn) Hooded Windmillgrass (Mariah) Shortspike Windmillgrass (Welder) Hairy Grama (Chaparral) Sand Lovegrass (Mason) Sand Dropseed (Borden County) Sand Bluestem (Cottle County) Partridge Pea (Comanche) Little Bluestem (OK Select) Englemann Daisy (Eldorado) Purple Prairie Clover (Cuero)	1.0 0.2 0.2 0.4 0.2 0.2 1.2 0.6 0.8 0.75 0.3
8 (Abilene) Feb. 1–May 15	Green Sprangletop (Van Horn) Sideoats Grama (Haskell) Texas Grama (Atascosa) Hairy Grama (Chaparral) Shortspike Windmillgrass (Welder) Little Bluestem (OK Select) Blue Grama (Hachita) Western Wheatgrass (Barton) Galleta Grass (Viva) Engelmann Daisy (Eldorado) Illinois Bundleflower (Sabine)	1.0 1.0 1.0 0.4 0.2 0.4 0.4 1.2 0.6 0.75 1.0	Green Sprangletop (Van Horn) Hooded Windmillgrass (Mariah) Shortspike Windmillgrass (Welder) Hairy Grama (Chaparral) Sand Lovegrass (Mason) Sand Dropseed (Borden County) Sand Bluestem (Cottle County) Partridge Pea (Comanche) Little Bluestem (OK Select) Englemann Daisy (Eldorado) Purple Prairie Clover (Cuero)	1.0 0.2 0.2 0.4 0.2 0.2 1.2 0.6 0.8 0.75 0.3
9 (Waco) Feb. 1–May 15	Green Sprangletop (Van Horn) Sideoats Grama (Haskell) Texas Grama (Atascosa) Hairy Grama (Chaparral) Shortspike Windmillgrass (Welder) Little Bluestem (OK Select) Purple Prairie Clover (Cuero) Engelmann Daisy (Eldorado) Illinois Bundleflower Awnless Bushsunflower (Plateau)	1.0 1.0 1.0 0.4 0.2 0.8 0.6 0.75 1.3 0.2	Green Sprangletop (Van Horn) Hooded Windmillgrass (Mariah) Shortspike Windmillgrass (Welder) Hairy Grama (Chaparral) Slender Grama (Dilley) Sand Lovegrass (Mason) Sand Dropseed (Borden County) Partridge Pea (Comanche) Little Bluestem (OK Select) Englemann Daisy (Eldorado) Purple Prairie Clover	1.0 0.2 0.2 0.4 1.0 0.2 0.2 0.6 0.8 0.75 0.3
10 (Tyler) Feb. 1–May 15	Green Sprangletop Bermudagrass Bahiagrass (Pensacola) Sideoats Grama (Haskell) Illinois Bundleflower	0.3 1.8 9.0 2.7 1.0	Green Sprangletop Bermudagrass Bahiagrass (Pensacola) Weeping Lovegrass (Ermelo) Sand Lovegrass Lance-Leaf Coreopsis	0.3 1.8 9.0 0.5 0.5 1.0
11 (Lufkin) Feb. 1–May 15	Green Sprangletop Bermudagrass Bahiagrass (Pensacola) Sideoats Grama (Haskell) Illinois Bundleflower	0.3 1.8 9.0 2.7 1.0	Green Sprangletop Bermudagrass Bahiagrass (Pensacola) Sand Lovegrass Lance-Leaf Coreopsis	0.3 2.1 9.0 0.5 1.0

Table 1 (continued)

Permanent Rural Seed Mix

District and Planting Dates	Clay Soils Species and Rates (lb. PLS/acre)		Sandy Soils Species and Rates (lb. PLS/acre)	
12 (Houston) Jan. 15–May 15	Green Sprangletop Bermudagrass Sideoats Grama (Haskell) Little Bluestem (Native) Illinois Bundleflower	0.3 2.1 3.2 1.4 1.0	Green Sprangletop Bermudagrass Bahiagrass (Pensacola) Weeping Lovegrass (Ermelo) Lance-Leaf Coreopsis	0.3 2.4 10.5 1.0 1.0
13 (Yoakum) Jan. 15–May 15	Green Sprangletop (Van Horn) Sideoats Grama (South Texas) Texas Grama (Atascosa) Slender Grama (Dilley) Shortspike Windmillgrass (Welder) Halls Panicum (Oso) Plains Bristlegrass (Catarina Blend) Canada Wildrye (Lavaca) Illinois Bundleflower (Sabine) Purple Prairie Clover (Cuero)	1.0 1.0 1.5 1.0 0.3 0.2 0.2 2.0 1.3 0.6	Green Sprangletop (Van Horn) Hooded Windmillgrass (Mariah) Slender Grama (Dilley) Hairy Grama (Chaparral) Shortspike Windmillgrass (Welder) Purple Prairie Clover (Cuero) Partridge Pea (Comanche) Englemann Daisy (Eldorado)	1.0 0.4 1.0 0.8 0.2 0.6 0.6 1.0
14 (Austin) Feb. 1–May 15	Green Sprangletop (Van Horn) Sideoats Grama (South Texas) Texas Grama (Atascosa) Hairy Grama (Chaparral) Shortspike Windmillgrass (Welder) Little Bluestem (OK Select) Purple Prairie Clover (Cuero) Engelmann Daisy (Eldorado) Illinois Bundleflower (Sabine) Awnless Bushsunflower (Plateau)	1.0 1.0 1.0 0.4 0.2 0.8 0.6 0.75 1.3 0.2	Green Sprangletop (Van Horn) Hooded Windmillgrass (Mariah) Shortspike Windmillgrass (Welder) Hairy Grama (Chaparral) Slender Grama (Dilley) Sand Lovegrass (Mason) Sand Dropseed (Borden County) Partridge Pea (Comanche) Little Bluestem (OK Select) Englemann Daisy (Eldorado) Purple Prairie Clover	1.0 0.2 0.2 0.4 1.0 0.2 0.2 0.6 0.8 0.75 0.3
15 (San Antonio) Feb. 1–May 1	Green Sprangletop (Van Horn) Sideoats Grama (South Texas) Texas Grama (Atascosa) Slender Grama (Dilley) Shortspike Windmillgrass (Welder) Pink Pappusgrass (Maverick) Halls Panicum (Oso) Plains Bristlegrass (Catarina Blend) False Rhodes Grass (Kinney) Hooded Windmillgrass (Mariah) Arizona Cottontop (La Salle)	1.0 1.0 1.0 1.0 0.2 0.6 0.2 0.2 0.1 0.2 0.2	Green Sprangletop (Van Horn) Slender Grama (Dilley) Hairy Grama (Chaparral) Shortspike Windmillgrass (Welder) Pink Pappusgrass (Maverick) Plains Bristlegrass (Catarina Blend) Hooded Windmillgrass (Mariah) Multi-flowered False Rhoades Grass (Hidalgo) Arizona Cottontop (La Salle)	1.0 2.0 0.6 0.4 0.6 0.2 0.3 0.1 0.2
16 (Corpus Christi) Jan. 1–May 1	Green Sprangletop (Van Horn) Sideoats Grama (South Texas) Texas Grama (Atascosa) Slender Grama (Dilley) Shortspike Windmillgrass (Welder) Pink Pappusgrass (Maverick) Halls Panicum (Oso) Plains Bristlegrass (Catarina Blend) False Rhodes Grass (Kinney) Hooded Windmillgrass (Mariah) Arizona Cottontop (La Salle)	1.0 1.0 1.0 1.0 0.2 0.6 0.2 0.2 0.1 0.2 0.2	Green Sprangletop (Van Horn) Slender Grama (Dilley) Hairy Grama (Chaparral) Shortspike Windmillgrass (Welder) Pink Pappusgrass (Maverick) Plains Bristlegrass (Catarina Blend) Hooded Windmillgrass (Mariah) Multi-flowered False Rhodes Grass (Hidalgo) Arizona Cottontop (La Salle)	1.0 2.0 0.6 0.4 0.6 0.2 0.3 0.1 0.2
17 (Bryan) Feb. 1–May 15	Green Sprangletop Bermudagrass Sideoats Grama (Haskell) Little Bluestem (Native) Illinois Bundleflower	0.3 1.5 3.6 1.7 1.0	Green Sprangletop Bermudagrass Bahiagrass (Pensacola) Weeping Lovegrass (Ermelo) Sand Lovegrass Lance-Leaf Coreopsis	0.3 1.5 7.5 0.6 0.6 1.0

Table 1 (continued)

Permanent Rural Seed Mix

District and Planting Dates	Clay Soils Species and Rates (lb. PLS/acre)		Sandy Soils Species and Rates (lb. PLS/acre)	
18 (Dallas) Feb. 1–May 15	Green Sprangletop (Van Horn) Sideoats Grama (Haskell) Texas Grama (Atascosa) Hairy Grama (Chaparral) Shortspike Windmillgrass (Welder) Little Bluestem (OK Select) Purple Prairie Clover (Cuero) Engelmann Daisy (Eldorado) Illinois Bundleflower Awnless Bushsunflower (Plateau)	1.0 1.0 1.0 0.4 0.2 0.8 0.6 0.75 1.3 0.2	Green Sprangletop (Van Horn) Hooded Windmillgrass (Mariah) Shortspike Windmillgrass (Welder) Hairy Grama (Chaparral) Slender Grama (Dilley) Sand Lovegrass (Mason) Sand Dropseed (Borden County) Partridge Pea (Comanche) Little Bluestem (OK Select) Englemann Daisy (Eldorado) Purple Prairie Clover	1.0 0.2 0.2 0.4 1.0 0.2 0.2 0.6 0.8 0.75 0.3
19 (Atlanta) Feb. 1–May 15	Green Sprangletop Bermudagrass Sideoats Grama (Haskell) Illinois Bundleflower	0.3 2.4 4.5 1.0	Green Sprangletop Bermudagrass Bahiagrass (Pensacola) Sand Lovegrass Lance-Leaf Coreopsis	0.3 2.1 7.5 0.6 1.0
20 (Beaumont) Jan. 15–May 15	Green Sprangletop Bermudagrass Sideoats Grama (Haskell) Illinois Bundleflower	0.3 2.7 4.1 1.0	Green Sprangletop Bermudagrass Bahiagrass (Pensacola) Sand Lovegrass Lance-Leaf Coreopsis	0.3 2.1 7.5 0.6 1.0
21 (Pharr) Jan. 15–May 15	Green Sprangletop (Van Horn) Sideoats Grama (South Texas) Texas Grama (Atascosa) Slender Grama (Dilley) Shortspike Windmillgrass (Welder) Pink Pappusgrass (Maverick) Halls Panicum (Oso) Plains Bristlegrass (Catarina Blend) False Rhodes Grass (Kinney) Hooded Windmillgrass (Mariah) Arizona Cottontop (La Salle)	1.0 1.0 1.0 1.0 0.2 0.6 0.2 0.2 0.1 0.2 0.2	Green Sprangletop (Van Horn) Slender Grama (Dilley) Hairy Grama (Chaparral) Shortspike Windmillgrass (Welder) Pink Pappusgrass (Maverick) Plains Bristlegrass (Catarina Blend) Hooded Windmillgrass (Mariah) Multi-flowered False Rhoades Grass (Hidalgo) Arizona Cottontop (La Salle)	1.0 2.0 0.6 0.4 0.6 0.2 0.3 0.1 0.2
22 (Laredo) Jan. 15–May 1	Green Sprangletop (Van Horn) Sideoats Grama (South Texas) Texas Grama (Atascosa) Slender Grama (Dilley) Shortspike Windmillgrass (Welder) Pink Pappusgrass (Maverick) Halls Panicum (Oso) Plains Bristlegrass (Catarina Blend) False Rhodes Grass (Kinney) Hooded Windmillgrass (Mariah) Arizona Cottontop (La Salle)	1.0 1.0 1.0 1.0 0.2 0.6 0.2 0.2 0.1 0.2 0.2	Green Sprangletop (Van Horn) Slender Grama (Dilley) Hairy Grama (Chaparral) Shortspike Windmillgrass (Welder) Pink Pappusgrass (Maverick) Plains Bristlegrass (Catarina Blend) Hooded Windmillgrass (Mariah) Multi-flowered False Rhoades Grass (Hidalgo) Arizona Cottontop (La Salle)	1.0 2.0 0.6 0.4 0.6 0.2 0.3 0.1 0.2
23 (Brownwood) Feb. 1–May 15	Green Sprangletop (Van Horn) Sideoats Grama (Haskell) Texas Grama (Atascosa) Hairy Grama (Chaparral) Shortspike Windmillgrass (Welder) Little Bluestem (OK Select) Blue Grama (Hachita) Western Wheatgrass (Barton) Galleta Grass (Viva) Engelmann Daisy (Eldorado) Awnless Bushsunflower (Plateau)	0.6 1.0 1.0 0.4 0.2 0.8 0.4 1.2 0.6 0.75 0.2	Green Sprangletop (Van Horn) Hooded Windmillgrass (Mariah) Shortspike Windmillgrass (Welder) Hairy Grama (Chaparral) Sand Lovegrass (Mason) Sand Dropseed (Borden County) Partridge Pea (Comanche) Little Bluestem (OK Select) Englemann Daisy (Eldorado) Purple Prairie Clover (Cuero)	1.0 0.2 0.2 0.4 0.2 0.2 0.6 0.8 0.75 0.3

Table 2 (continued)

Permanent Urban Seed Mix

District and Planting Dates	Clay Soils Species and Rates (lb. PLS/acre)		Sandy Soils Species and Rates (lb. PLS/acre)	
24 (El Paso) Feb. 1–May 15	Green Sprangletop (Van Horn) Sideoats Grama (South Texas) Blue Grama (Hachita) Galleta Grass (Viva) Shortspike Windmillgrass (Welder) Pink Pappusgrass (Maverick) Alkali Sacaton (Saltalk) Plains Bristlegrass (Catarina Blend) False Rhodes Grass (Kinney) Whiplash Pappusgrass (Webb) Arizona Cottontop (La Salle)	1.0 1.0 0.4 0.6 0.2 0.6 0.2 0.2 0.1 0.6 0.2	Green Sprangletop (Van Horn) Hooded Windmillgrass (Mariah) Blue Grama (Hachita) Hairy Grama (Chaparral) Sand Lovegrass (Mason) Sand Dropseed (Borden County) Indian Ricegrass (Rim Rock) Sand Bluestem (Cottle County) Little Bluestem (Pastura) Purple Prairie Clover (Cuero)	1.0 0.2 0.4 0.4 0.2 0.2 1.6 1.2 0.8 0.3
25 (Childress) Feb. 1–May 15	Green Sprangletop Sideoats Grama (El Reno) Blue Grama (Hachita) Western Wheatgrass Galleta Illinois Bundleflower	0.3 2.7 0.9 2.1 1.6 1.0	Green Sprangletop Weeping Lovegrass (Ermelo) Sand Dropseed (Borden Co.) Sand Lovegrass Purple Prairie Clover	0.3 1.2 0.5 0.8 0.5

Table 2
Permanent Urban Seed Mix

District and Planting Dates	Clay Soils Species and Rates (lb. PLS/acre)		Sandy Soils Species and Rates (lb. PLS/acre)	
1 (Paris) Feb. 1–May 15	Green Sprangletop Bermudagrass Sideoats Grama (Haskell)	0.3 2.4 4.5	Green Sprangletop Bermudagrass	0.3 5.4
2 (Ft. Worth) Feb. 1–May 15	Green Sprangletop Sideoats Grama (El Reno) Bermudagrass Buffalograss (Texoka)	0.3 3.6 2.4 1.6	Green Sprangletop Sideoats Grama (El Reno) Bermudagrass Sand Dropseed (Borden Co.)	0.3 3.6 2.1 0.3
3 (Wichita Falls) Feb. 1–May 15	Green Sprangletop Sideoats Grama (El Reno) Bermudagrass Buffalograss (Texoka)	0.3 4.5 1.8 1.6	Green Sprangletop Sideoats Grama (El Reno) Bermudagrass Sand Dropseed (Borden Co.)	0.3 3.6 1.8 0.4
4 (Amarillo) Feb. 15–May 15	Green Sprangletop Sideoats Grama (El Reno) Blue Grama (Hachita) Buffalograss (Texoka)	0.3 3.6 1.2 1.6	Green Sprangletop Sideoats Grama (El Reno) Blue Grama (Hachita) Sand Dropseed (Borden Co.) Buffalograss (Texoka)	0.3 2.7 0.9 0.4 1.6
5 (Lubbock) Feb. 15–May 15	Green Sprangletop Sideoats Grama (El Reno) Blue Grama (Hachita) Buffalograss (Texoka)	0.3 3.6 1.2 1.6	Green Sprangletop Sideoats Grama (El Reno) Blue Grama (Hachita) Sand Dropseed (Borden Co.) Buffalograss (Texoka)	0.3 2.7 0.9 0.4 1.6
6 (Odessa) Feb. 1–May 15	Green Sprangletop Sideoats Grama (Haskell) Blue Grama (Hachita) Buffalograss (Texoka)	0.3 3.6 1.2 1.6	Green Sprangletop Sideoats Grama (Haskell) Sand Dropseed (Borden Co.) Blue Grama (Hachita) Buffalograss (Texoka)	0.3 2.7 0.4 0.9 1.6
7 (San Angelo) Feb. 1–May 1	Green Sprangletop Sideoats Grama (Haskell) Buffalograss (Texoka)	0.3 7.2 1.6	Green Sprangletop Sideoats Grama (Haskell) Sand Dropseed (Borden Co.) Blue Grama (Hachita) Buffalograss (Texoka)	0.3 3.2 0.3 0.9 1.6
8 (Abilene) Feb. 1–May 15	Green Sprangletop Sideoats Grama (Haskell) Blue Grama (Hachita) Buffalograss (Texoka)	0.3 3.6 1.2 1.6	Green Sprangletop Sand Dropseed (Borden Co.) Sideoats Grama (Haskell) Blue Grama (Hachita) Buffalograss (Texoka)	0.3 0.3 3.6 0.8 1.6
9 (Waco) Feb. 1–May 15	Green Sprangletop Bermudagrass Buffalograss (Texoka) Sideoats Grama (Haskell)	0.3 1.8 1.6 4.5	Green Sprangletop Buffalograss (Texoka) Bermudagrass Sand Dropseed (Borden Co.)	0.3 1.6 3.6 0.4

District and Planting Dates	Clay Soils Species and Rates (lb. PLS/acre)		Sandy Soils Species and Rates (lb. PLS/acre)	
10 (Tyler) Feb. 1–May 15	Green Sprangletop Bermudagrass Sideoats Grama (Haskell)	0.3 2.4 4.5	Green Sprangletop Bermudagrass	0.3 5.4
11 (Lufkin) Feb. 1–May 15	Green Sprangletop Bermudagrass Sideoats Grama (Haskell)	0.3 2.4 4.5	Green Sprangletop Bermudagrass	0.3 5.4
12 (Houston) Jan. 15–May 15	Green Sprangletop Sideoats Grama (Haskell) Bermudagrass	0.3 4.5 2.4	Green Sprangletop Bermudagrass	0.3 5.4
13 (Yoakum) Jan. 15–May 15	Green Sprangletop Sideoats Grama (South Texas) Bermudagrass	0.3 4.5 2.4	Green Sprangletop Bermudagrass	0.3 5.4
14 (Austin) Feb. 1–May 15	Green Sprangletop Bermudagrass Sideoats Grama (South Texas) Buffalograss (Texoka)	0.3 2.4 3.6 1.6	Green Sprangletop Bermudagrass Buffalograss (Texoka)	0.3 4.8 1.6
15 (San Antonio) Feb. 1–May 1	Green Sprangletop Sideoats Grama (South Texas) Bermudagrass Buffalograss (Texoka)	0.3 3.6 2.4 1.6	Green Sprangletop Bermudagrass Buffalograss (Texoka)	0.3 4.8 1.6
16 (Corpus Christi) Jan. 1–May 1	Green Sprangletop Sideoats Grama (South Texas) Bermudagrass Buffalograss (Texoka)	0.3 3.6 2.4 1.6	Green Sprangletop Bermudagrass Buffalograss (Texoka)	0.3 4.8 1.6
17 (Bryan) Feb. 1–May 15	Green Sprangletop Bermudagrass Sideoats Grama (Haskell)	0.3 2.4 4.5	Green Sprangletop Bermudagrass	0.3 5.4
18 (Dallas) Feb. 1–May 15	Green Sprangletop Sideoats Grama (El Reno) Buffalograss (Texoka) Bermudagrass	0.3 3.6 1.6 2.4	Green Sprangletop Buffalograss (Texoka) Bermudagrass Sand Dropseed (Borden Co.)	0.3 1.6 3.6 0.4
19 (Atlanta) Feb. 1–May 15	Green Sprangletop Bermudagrass Sideoats Grama (Haskell)	0.3 2.4 4.5	Green Sprangletop Bermudagrass	0.3 5.4
20 (Beaumont) Jan. 15–May 15	Green Sprangletop Bermudagrass Sideoats Grama (Haskell)	0.3 2.4 4.5	Green Sprangletop Bermudagrass	0.3 5.4
21 (Pharr) Jan. 15–May 15	Green Sprangletop Sideoats Grama (South Texas) Buffalograss (Texoka) Bermudagrass	0.3 3.6 1.6 2.4	Green Sprangletop Buffalograss (Texoka) Bermudagrass Sand Dropseed (Borden Co.)	0.3 1.6 3.6 0.4
22 (Laredo) Jan. 15–May 1	Green Sprangletop Sideoats Grama (South Texas) Buffalograss (Texoka) Bermudagrass	0.3 4.5 1.6 1.8	Green Sprangletop Buffalograss (Texoka) Bermudagrass Sand Dropseed	0.3 1.6 3.6 0.4
23 (Brownwood) Feb. 1–May 15	Green Sprangletop Sideoats Grama (Haskell) Bermudagrass Blue Grama (Hachita)	0.3 3.6 1.2 0.9	Green Sprangletop Buffalograss (Texoka) Bermudagrass Sand Dropseed (Borden Co.)	0.3 1.6 3.6 0.4
24 (El Paso) Feb. 1–May 15	Green Sprangletop Sideoats Grama (South Texas) Blue Grama (Hachita) Buffalograss (Texoka)	0.3 3.6 1.2 1.6	Green Sprangletop Buffalograss (Texoka) Sand Dropseed (Borden Co.) Blue Grama (Hachita)	0.3 1.6 0.4 1.8
25 (Childress) Feb. 1–May 15	Green Sprangletop Sideoats Grama (El Reno) Blue Grama (Hachita) Buffalograss (Texoka)	0.3 3.6 1.2 1.6	Green Sprangletop Sand Dropseed (Borden Co.) Buffalograss (Texoka) Bermudagrass	0.3 0.4 1.6 1.8

Table 3
Temporary Cool Season Seeding

Districts	Dates	Seed Mix and Rates (lb. PLS/acre)	
Paris (1), Amarillo (4), Lubbock (5), Dallas (18)	September 1–November 30	Tall Fescue Western Wheatgrass Wheat (Red, Winter)	4.5 5.6 34
Odessa (6), San Angelo (7), El Paso (24)	September 1–November 30	Western Wheatgrass Wheat (Red, Winter)	8.4 50
Waco (9), Tyler (10), Lufkin (11), Austin (14), San Antonio (15), Bryan (17), Atlanta (19)	September 1–November 30	Tall Fescue Oats Wheat	4.5 24 34
Houston (12), Yoakum (13), Corpus Christi (16), Beaumont (20), Pharr (21), Laredo (22)	September 1–November 30	Oats	72
Ft. Worth (2), Wichita Falls (3), Abilene (8), Brownwood (23), Childress (25)	September 1–November 30	Tall Fescue Western Wheatgrass Cereal Rye	4.5 5.6 34

Table 4
Temporary Warm Season Seeding

Districts	Dates	Seed Mix and Rates (lb. PLS/acre)	
All	May 1–August 31	Foxtail Millet	34

2.2. Fertilizer. Use fertilizer in conformance with Article 166.2., "Materials."

2.3. Vegetative Watering. Use water that is clean and free of industrial wastes and other substances harmful to the growth of vegetation.

2.4. Mulch.

2.4.1. Straw or Hay Mulch. Use straw or hay mulch in conformance with Section 162.2.5., "Mulch."

2.4.2. Cellulose Fiber Mulch. Use only cellulose fiber mulches that are on the Approved Products List, *Erosion Control Approved Products*. (http://www.txdot.gov/business/resources/erosion-control.html) Submit one full set of manufacturer's literature for the selected material. Keep mulch dry until applied. Do not use molded or rotted material.

2.5. Tacking Methods. Use a tacking agent applied in accordance with the manufacturer's recommendations or a crimping method on all straw or hay mulch operations. Use tacking agents as approved or as specified on the plans.

3. CONSTRUCTION

Cultivate the area to a depth of 4 in. before placing the seed unless otherwise directed. Use approved equipment to vertically track the seedbed as shown on the plans or as directed. Cultivate the seedbed to a depth of 4 in. or mow the area before placement of the permanent seed when performing permanent seeding after an established temporary seeding. Plant the seed specified and mulch, if required, after the area has been completed to lines and grades as shown on the plans.

3.1. Broadcast Seeding. Distribute the seed or seed mixture uniformly over the areas shown on the plans using hand or mechanical distribution or hydro-seeding on top of the soil unless otherwise directed. Apply the mixture to the area to be seeded within 30 min. of placement of components in the equipment when seed and water are to be distributed as a slurry during hydro-seeding. Roll the planted area with a light roller or other suitable equipment. Roll sloped areas along the contour of the slopes.

3.2. Straw or Hay Mulch Seeding. Plant seed according to Section 164.3.1., "Broadcast Seeding." Apply straw or hay mulch uniformly over the seeded area immediately after planting the seed or seed mixture. Apply

straw mulch at 2 to 2.5 tons per acre. Apply hay mulch at 1.5 to 2 tons per acre. Use a tacking method over the mulched area.

3.3. Cellulose Fiber Mulch Seeding. Plant seed in accordance with Section 164.3.1., "Broadcast Seeding." Apply cellulose fiber mulch uniformly over the seeded area immediately after planting the seed or seed mixture at the following rates.

- Sandy soils with slopes of 3:1 or less—2,500 lb. per acre.
- Sandy soils with slopes greater than 3:1—3,000 lb. per acre.
- Clay soils with slopes of 3:1 or less—2,000 lb. per acre.
- Clay soils with slopes greater than 3:1—2,300 lb. per acre.

Cellulose fiber mulch rates are based on dry weight of mulch per acre. Mix cellulose fiber mulch and water to make a slurry and apply uniformly over the seeded area using suitable equipment.

3.4. Drill Seeding. Plant seed or seed mixture uniformly over the area shown on the plans at a depth of 1/4 to 1/3 in. using a pasture or rangeland type drill unless otherwise directed. Plant seed along the contour of the slopes.

3.5. Straw or Hay Mulching. Apply straw or hay mulch uniformly over the area as shown on the plans. Apply straw mulch at 2 to 2.5 tons per acre. Apply hay mulch at 1.5 to 2 tons per acre. Use a tacking method over the mulched area.

Apply fertilizer in conformance with Article 166.3., "Construction." Seed and fertilizer may be distributed simultaneously during "Broadcast Seeding" operations, provided each component is applied at the specified rate. Apply half of the required fertilizer during the temporary seeding operation and the other half during the permanent seeding operation when temporary and permanent seeding are both specified for the same area.

Water the seeded areas at the rates and frequencies as shown on the plans or as directed.

4. MEASUREMENT

This Item will be measured by the square yard or by the acre.

5. PAYMENT

The work performed and the materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Broadcast Seeding (Perm)" of the rural or urban seed mixture and sandy or clay soil specified, "Broadcast Seeding (Temp)" of warm or cool season specified, "Straw or Hay Mulch Seeding (Perm)" of the rural or urban seed mixture and sandy or clay soil specified, "Straw or Hay Mulch Seeding (Temp)" of warm or cool season specified, "Cellulose Fiber Mulch Seeding (Perm)" of the rural or urban seed mixture and sandy or clay soil specified, "Cellulose Fiber Mulch Seeding (Temp)" of warm or cool season specified, "Drill Seeding (Perm)" of the rural or urban seed mixture and sandy or clay soil specified, "Drill Seeding (Temp)" of warm or cool season specified, and "Straw or Hay Mulching." This price is full compensation for furnishing materials, including water for hydro-seeding and hydro-mulching operations, mowing, labor, equipment, tools, supplies, and incidentals. Fertilizer will not be paid for directly but will be subsidiary to this Item. Water for irrigating the seeded area, when specified, will be paid for under Item 168, "Vegetative Watering."

Item 193
Landscape Establishment

1. DESCRIPTION

Establish landscape plantings and maintain landscaped areas at designated locations. Begin this Item after the final payment is approved in accordance with Section 192.5.4., "Final Payment," if used with Item 192, "Landscape Planting."

2. MATERIALS

Furnish the following materials unless otherwise shown on the plans:

- fertilizer in accordance with Article 166.2., "Materials;"
- mulch consisting of loose organic materials such as wood chips or shredded bark that is free from harmful chemicals, soil, and other foreign matter that may promote compaction of the mulch or cause injury to the plants;
- water that is clean and free of industrial wastes and other substances harmful to the growth of vegetation;
- replacement plants as originally installed or as approved;
- pesticides conforming to the requirements of Section 193.3.1., "Plant Maintenance;"
- supports of the same type as originally installed or as approved; and
- irrigation system replacement parts of the same type and manufacturer as originally installed or approved equal.

3. WORK METHODS

Inspect the site at least every 2 weeks, and perform the required maintenance when "Plant Maintenance" or "Irrigation System Operation and Maintenance" are measured by the month. Perform the following maintenance activities, and conform to requirements shown on the plans.

3.1. **Plant Maintenance**. Maintain vegetation within the site in a healthy and vigorous growing condition. Apply pesticides, when required, under the supervision of a person possessing a license in the appropriate use category issued by the Texas Department of Agriculture. Provide documentation of this license, and obtain approval of the pesticides before applications. Ensure pesticide applications conform to label directions and all pertinent laws and regulations.

3.1.1. **Pruning**. Prune in accordance with ANSI A300 (Part 1) when shown on the plans. Remove dead or dying plants and dead, diseased, or damaged limbs on trees and shrubs. Remove sucker-growth on trunks of trees. Apply an approved wound dressing to all oak (Quercus) species within 20 min. of causing bark damage or making a pruning cut. Remove and dispose of pruning debris.

3.1.2. **Insect, Disease, and Animal Control**. Notify the Engineer in writing of problems with insects, diseases, or animals as such problems arise. Treat the plants or planted areas as directed.

3.1.3. **Fertilization**. Apply fertilizer uniformly to all plants designated to receive fertilizer.

3.1.4. **Mulching, Plant Basin, and Plant Bed Maintenance**. Physically remove or apply herbicide to weeds and grasses within plant basins and plant beds before placing additional mulch. Apply and maintain mulch at a depth of 2 in. Maintain plant basins and plant beds free of weeds and grasses, except those that have been

treated with herbicides may remain in place until removal is directed. Reshape plant basins and plant beds as necessary to conform to plan details.

3.1.5. **Mowing, Trimming, and Edging**. Remove and dispose of litter within the designated areas before mowing. Mow and trim grassed areas at the designated height and frequency. Edge where required. Do not use nylon cord trimmers inside plant basins or inside beds containing plant material. Trim vegetation and remove debris from curbs, sidewalks, and other hardscape features.

3.1.6. **Staking, Guying, and Bracing of Plants**. Stake, guy, or brace plants as directed. Remove support materials when directed, and dispose of removed materials.

3.2. **Plant Replacement**. Remove plants selected by the Engineer and replace with plants of the original species, size, and characteristics or with approved substitutes, if required on the plans. Replace plants that have been damaged or killed due to the actions or negligence of the Contractor at no additional cost to the Department. Replace plants within the next scheduled work period following notification to begin replacement unless otherwise directed. Backfill in conformance with the plans or as directed.

3.3. **Vegetative Watering**. Apply water at the designated rate and frequency to plants or planting areas not serviced by an existing irrigation system. Apply water as directed, adjusting rate and frequency to provide adequate moisture to plant material. Use watering equipment with accurate measuring devices.

3.4. **Irrigation System Operation and Maintenance**. Maintain the system under the supervision of a person possessing an irrigator's license issued by the TCEQ, and provide documentation of this license. Verify and adhere to all local, state, and federal regulations. Coordinate and obtain required backflow preventer testing at no cost to the Department. Operate the system using water provided by the Department unless otherwise shown on the plans. Ensure that all zones are functioning properly and providing adequate moisture to plant material using an approved watering schedule. Winterize the system, when required, to prevent freeze damage in locations where temperatures fall below 32°F. Repair the system using replacement parts of the same type and manufacturer as originally installed or an approved equal. Provide plant irrigation by an approved alternate method at no cost to the Department if the system fails due to the Contractor's actions or neglect.

4. MEASUREMENT

"Plant Maintenance" will be measured by the month or by the cycle. "Plant Replacement" will be measured by each plant. "Vegetative Watering" will be measured by the 1,000 gal. of water. "Irrigation System Operation and Maintenance" will be measured by the month.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Plant Maintenance," "Plant Replacement" of the size specified, "Plant Replacement" of the size and type specified, "Plant Replacement" of the group specified, "Vegetative Watering," and "Irrigation System Operation and Maintenance." This price is full compensation for furnishing and operating equipment and for litter pickup, mowing, trimming, edging, pruning, fertilizer, labor, materials, tools, and incidentals. Plant replacement needed due to Contractor negligence will be at no additional cost to the Department.

Item 210
Rolling

1. DESCRIPTION

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

2. EQUIPMENT

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

Table 1
Roller Requirements[1]

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

1. Unless otherwise specified in the Contract.

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

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

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

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

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

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

Equip drums with tamping feet that:

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

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

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

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

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

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

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

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

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

without damaging the surface. Moisten the wheels with water or an approved asphalt release agent when necessary.

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

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

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

2.4.2. **Medium Pneumatic Tire**. Furnish a unit:

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

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

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

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

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

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

3. CONSTRUCTION

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

4. MEASUREMENT AND PAYMENT

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

Item 216
Proof Rolling

1. DESCRIPTION

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

2. EQUIPMENT

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

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

3. CONSTRUCTION

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

4. MEASUREMENT

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

5. PAYMENT

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

Item 247
Flexible Base

1. DESCRIPTION

Construct a foundation course composed of flexible base.

2. MATERIALS

Furnish uncontaminated materials of uniform quality that meet the requirements of the plans and specifications. Notify the Engineer of the proposed material sources and of changes to material sources. The Engineer may sample and test project materials at any time before compaction throughout the duration of the project to assure specification compliance. Use Tex-100-E material definitions.

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

Table 1
Material Requirements

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

3. EQUIPMENT

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

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

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

4. CONSTRUCTION

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

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

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

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

4.1. **Preparation of Subgrade or Existing Base**. Remove or scarify existing asphalt concrete pavement in accordance with Item 105, “Removing Treated and Untreated Base and Asphalt Pavement,” when shown on

the plans or as directed. Shape the subgrade or existing base to conform to the typical sections shown on the plans or as directed.

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

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

4.2. **Placing**. Spread and shape flexible base into a uniform layer with an approved spreader the same day as delivered unless otherwise approved. Construct layers to the thickness shown on the plans. Maintain the shape of the course. Control dust by sprinkling, as directed. Correct or replace segregated areas as directed, at no additional expense to the Department.

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

4.3. **Compaction**. Compact using density control unless otherwise shown on the plans. Multiple lifts are permitted when shown on the plans or approved. Bring each layer to the moisture content directed. When necessary, sprinkle the material in accordance with Item 204, "Sprinkling."

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

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

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

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

4.3.2. **Density Control**. Compact to at least 100% of the maximum dry density determined by Tex-113-E, unless otherwise shown on the plans. Maintain moisture during compaction within ±2 percentage points of the optimum moisture content as determined by Tex-113-E. Measure the moisture content of the material in accordance with Tex-115-E or Tex-103-E during compaction daily and report the results the same day to the Engineer, unless otherwise shown on the plans or directed. Do not achieve density by drying the material after compaction.

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

4.4. **Finishing**. After completing compaction, clip, skin, or tight-blade the surface with a maintainer or subgrade trimmer to a depth of approximately 1/4 in. Remove loosened material and dispose of it at an approved location. Seal the clipped surface immediately by rolling with a pneumatic tire roller until a smooth surface is

attained. Add small increments of water as needed during rolling. Shape and maintain the course and surface in conformity with the typical sections, lines, and grades as shown on the plans or as directed.

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

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

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

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

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

5. MEASUREMENT

Flexible base will be measured as follows:

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

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

Measurement is further defined for payment as follows.

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

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

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

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

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

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

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for the types of work shown below. No additional payment will be made for thickness or width exceeding that shown on the typical section or provided on the plans for cubic yard in the final position or square yard measurement.

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

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

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

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

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

Item 251
Reworking Base Courses

1. DESCRIPTION

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

2. MATERIALS

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

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

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

3. EQUIPMENT

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

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

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

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

4. CONSTRUCTION

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

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

4.1. **Types of Work**.

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

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

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

4.1.4. **Type D**. Refinishing.

4.2. **Performance of Work**.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

5. MEASUREMENT

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

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

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

Measurement is further defined for payment as follows.

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

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

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

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

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

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

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Reworking Base Material" for the type, scarified depth, and compaction method shown on the plans. For cubic yard measurements, the measurement location (vehicle, stockpile, or original position) will be specified. No additional payment will be made for thickness or width exceeding that shown on the typical sections or provided on the plans for station, square yard, and cubic yard in the original position measurement. This price is full compensation for furnishing and disposing of materials, blading, brooming, scarifying, salvaging, replacing, stockpiling, reshaping, refinishing, compacting, finishing, curing, and equipment, labor, tools, and incidentals.

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

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

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

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

Additional restrictions for measurement and payment are as follows:

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

Item 260
Lime Treatment (Road-Mixed)

1. DESCRIPTION

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

2. MATERIALS

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

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

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

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

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

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

2.6. **Mix Design**. The Engineer will determine the target lime content and optimum moisture content in accordance with Tex-121-E or prior experience with the project materials. The Contractor may propose a mix design developed in accordance with Tex-121-E. The Engineer will use Tex-121-E to verify the Contractor's proposed mix design before acceptance. Reimburse the Department for subsequent mix designs or partial designs necessitated by changes in the material or requests by the Contractor. Limit the amount of recycled asphalt pavement to no more than 50% of the mix unless otherwise shown on the plans or directed.

3. EQUIPMENT

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

3.1. **Storage Facility**. Store quicklime and dry hydrated lime in closed, weatherproof containers.

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

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

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

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

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

4. CONSTRUCTION

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

4.1. **Preparation of Subgrade or Existing Base for Treatment**. Before treating, remove existing asphalt pavement in accordance with Item 105, "Removing Treated and Untreated Base and Asphalt Pavement," when shown on the plans or as directed. Shape existing material in accordance with applicable bid items to conform to typical sections shown on the plans and as directed.

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

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

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

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

4.3. **Application of Lime**. Uniformly apply lime using dry or slurry placement as shown on the plans or as directed. Add lime at the percentage determined in Section 260.2.6., "Mix Design." Apply lime only on an area where mixing can be completed during the same working day.

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

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

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

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

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

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

Thoroughly mix the material and lime using approved equipment. When treating subgrade, bring the moisture content above the optimum moisture content to insure adequate chemical reaction of the lime and subgrade materials. Allow the mixture to mellow for 1 to 4 days, as directed. When pebble grade quicklime is used, allow the mixture to mellow for 2 to 4 days, as directed. Sprinkle the treated materials during the mixing and mellowing operation, as directed, to achieve adequate hydration and proper moisture content. When the material to be treated has a sulfate content greater than 3,000 ppm but less than or equal to 7,000 ppm, mellow for a minimum of 7 days. Maintain in a continuously moist condition by sprinkling in accordance with Item 204, "Sprinkling." After mellowing, resume mixing until a homogeneous, friable mixture is obtained. After mixing, the Engineer may sample the mixture at roadway moisture and test in accordance with Tex-101-E, Part III, to determine compliance with the gradation requirements in Table 1.

Table 1
Gradation Requirements (Minimum % Passing)

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

4.5. **Compaction**. Compact the mixture using density control, unless otherwise shown on the plans. Multiple lifts are permitted when shown on the plans or approved. Bring each layer to the moisture content directed. Sprinkle the treated material in accordance with Item 204, "Sprinkling" or aerate the treated material to adjust the moisture content during compaction so that it is no more than 1.0 percentage points below optimum and 2.0 percentage points above optimum as determined by Tex-121-E. Measure the moisture content of the material in accordance with Tex-115-E or Tex-103-E during compaction daily and report the results the same day, unless otherwise shown on the plans or directed.

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

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

Rework, recompact, and refinish material that fails to meet or that loses required moisture, density, stability, or finish before the next course is placed or the project is accepted. Continue work until specification requirements are met. Rework in accordance with Section 260.4.6., "Reworking a Section." Perform the work at no additional expense to the Department.

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

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

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

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

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

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

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

Correct grade deviations of constructed base greater than 1/4 in. in 16 ft. measured longitudinally or greater than 1/4 in. over the entire width of the cross-section in areas where surfacing is to be placed. Remove excess material, reshape, and roll with a pneumatic-tire roller. Correct as directed if material is more than 1/4 in. low. Do not surface patch. The 72-hr. time limit required for completion of placement, compaction, and finishing does not apply to finishing required just before applying the surface course.

4.8. **Curing**. Cure for the minimum number of days shown in Table 2 by sprinkling in accordance with Item 204, "Sprinkling," or by applying an asphalt material at a rate of 0.05 to 0.20 gal. per square yard as directed. Maintain moisture during curing. Upon completion of curing, maintain the moisture content in accordance with Section 132.3.5., "Maintenance of Moisture and Reworking," for subgrade and Section 247.4.5., "Curing"

for bases before placing subsequent courses. Do not allow equipment on the finished course during curing except as required for sprinkling, unless otherwise approved. Apply seals or additional courses within 14 calendar days of final compaction.

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

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

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

5. MEASUREMENT

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

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

5.1.1. **Hydrated Lime**.

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

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

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

5.1.3. **Quicklime**.

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

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

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

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

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid in accordance with Section 260.6.1., "Lime," and Section 260.6.2., "Lime Treatment."

Furnishing and delivering new base will be paid for in accordance with Section 247.6.2., "Flexible Base (Roadway Delivery)." Mixing, spreading, blading, shaping, compacting, and finishing new or existing base

material will be paid for in accordance with Section 260.6.2., "Lime Treatment." Removal and disposal of existing asphalt concrete pavement will be paid for in accordance with pertinent Items or Article 4.4., "Changes in the Work."

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

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

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

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

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

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

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

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

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

Item 275
Cement Treatment (Road-Mixed)

1. DESCRIPTION

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

2. MATERIALS

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

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

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

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

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

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

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

3. EQUIPMENT

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

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

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

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

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

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

4. CONSTRUCTION

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

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

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

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

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

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

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

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

4.3.1. **Dry Placement**. Before applying cement, bring the prepared roadway to approximately optimum moisture content. When necessary, sprinkle in accordance with Item 204, “Sprinkling.” Distribute the required quantity of dry cement with approved equipment. Minimize dust and scattering of cement by wind. Do not apply

cement when wind conditions, in the opinion of the Engineer, cause blowing cement to become dangerous to traffic or objectionable to adjacent property owners.

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

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

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

Table 1
Gradation Requirements Minimum % Passing

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

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

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

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

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

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

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

4.5.2. **Density Control**. Achieve at least 95% of the maximum density determined in accordance with Tex-120-E when compaction is complete. The Engineer will determine roadway density and moisture content in accordance with Tex-115-E. The Engineer may verify strength in accordance with Tex-120-E and adjust

cement content to achieve the target strength for work going forward. Remove material that does not meet density requirements or rework by adding the target cement content, reshaping, recompacting, and refinishing at the Contractor's expense.

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

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

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

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

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

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

5. MEASUREMENT

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

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

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

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

6. PAYMENT

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

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

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

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

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

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

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

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

Item 300
Asphalts, Oils, and Emulsions

1. DESCRIPTION

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

2. MATERIALS

Provide asphalt materials that meet the stated requirements when tested in accordance with the referenced Department, AASHTO, and ASTM test methods. Use asphalt containing recycled materials only if the recycled components meet the requirements of Article 6.9, "Recycled Materials." Provide asphalt materials that have been preapproved for use by the Construction Division in accordance with Tex-545-C.

Acronyms used in this Item are defined in Table 1.

Table 1
Acronyms

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

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

Table 2
Asphalt Cement

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

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

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

Table 3
Polymer-Modified Asphalt Cement

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

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

Table 4
Rapid-Curing Cutback Asphalt

Property	Test Procedure	Type–Grade					
		RC-250		RC-800		RC-3000	
		Min	Max	Min	Max	Min	Max
Kinematic viscosity, 140°F, cSt	T 201	250	400	800	1,600	3,000	6,000
Water, %	D95	–	0.2	–	0.2	–	0.2
Flash point, T.O.C., °F	T 79	80	–	80	–	80	–
Distillation test:	T 78						
Distillate, percentage by volume of total distillate to 680°F							
to 437°F		40	75	35	70	20	55
to 500°F		65	90	55	85	45	75
to 600°F		85	–	80	–	70	–
Residue from distillation, volume %		70	–	75	–	82	–
Tests on distillation residue:							
Viscosity, 140°F, poise	T 202	600	2400	600	2400	600	2400
Ductility, 5 cm/min., 77°F, cm	T 51	100	–	100	–	100	–
Solubility in trichloroethylene, %	T 44	99.0	–	99.0	–	99.0	–
Spot test	Tex-509-C	Neg.		Neg.		Neg.	

Table 5
Medium-Curing Cutback Asphalt

Property	Test Procedure	Type–Grade							
		MC-30		MC-250		MC-800		MC-3000	
		Min	Max	Min	Max	Min	Max	Min	Max
Kinematic viscosity, 140°F, cSt	T 201	30	60	250	500	800	1,600	3,000	6,000
Water, %	D95	–	0.2	–	0.2	–	0.2	–	0.2
Flash point, T.O.C., °F	T 79	95	–	122	–	140	–	149	–
Distillation test:	T 78								
Distillate, percentage by volume of total distillate to 680°F									
to 437°F		–	35	–	20	–	–	–	–
to 500°F		30	75	5	55	–	40	–	15
to 600°F		75	95	60	90	45	85	15	75
Residue from distillation, volume %		50	–	67	–	75	–	80	–
Tests on distillation residue:									
Viscosity, 140°F, poise	T 202	300	1200	300	1200	300	1200	300	1200
Ductility, 5 cm/min., 77°F, cm	T 51	100	–	100	–	100	–	100	–
Solubility in trichloroethylene, %	T 44	99.0	–	99.0	–	99.0	–	99.0	–
Spot test	Tex-509-C	Neg.		Neg.		Neg.		Neg.	

Table 6
Special-Use Cutback Asphalt

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

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

Table 7
Emulsified Asphalt

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

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

Table 8
Cationic Emulsified Asphalt

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

Table 9
Polymer-Modified Emulsified Asphalt

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

Property	Test	Type–Grade

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

Table 10
Polymer-Modified Cationic Emulsified Asphalt

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

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

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

Table 11
Specialty Emulsions

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

Supply with each shipment of PCE:

- a copy of a lab report from an approved analytical lab, signed by a lab official, indicating the PCE formulation does not meet any characteristics of a Resource Conservation Recovery Act (RCRA) hazardous waste;
- a certification from the producer that the formulation supplied does not differ from the one tested and that no listed RCRA hazardous wastes or Polychlorinated Biphenyls (PCBs) have been mixed with the product; and
- a Safety Data Sheet.

Exception to T 59: In dilution, use 350 mL of distilled or deionized water and a 1,000-mL beaker.
Use Tex-238-F, beginning at "Particle Size Analysis by Laser Diffraction," with distilled or deionized water as a medium and no dispersant, or use another approved method.
Exception to T 59: Leave sample in the oven until foaming ceases, then cool and weigh.
PCE must meet either the kinematic viscosity requirement or the particle size requirement.

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

Table 12
Recycling Agent and Emulsified Recycling Agent

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

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

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

CRM must be:

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

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

Table 13
CRM Gradations

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

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

Table 14
Polymer-Modified Asphalt-Emulsion Crack Sealer

Property	Test Procedure	Min	Max
Rotational viscosity, 77°F, cP	D 2196, Method A	10,000	25,000
Sieve test, %	T 59	–	0.1
Storage stability, 1 day, %	T 59	–	1
Evaporation	Tex-543-C		
Residue by evaporation, % by wt.		65	–
Tests on residue from evaporation:			
Penetration, 77°F, 100 g, 5 sec.	T 49	35	75
Softening point, °F	T 53	140	–
Ductility, 39.2°F, 5 cm/min., cm	T 51	100	–

Table 15
Rubber-Asphalt Crack Sealer

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

1. Provide certification that the Min % virgin rubber was added.
2. Agitate the sealing compound with a 3/8- to 1/2-in. (9.5- to 12.7-mm) wide, square-end metal spatula to bring the material on the bottom of the cup to the surface (i.e., turn the material over) before passing the test flame over the cup. Start at one side of the thermometer, move around to the other, and then return to the starting point using 8 to 10 rapid circular strokes. Accomplish agitation in 3 to 4 sec. Pass the test flame over the cup immediately after stirring is completed.
3. Exception to T 49: Substitute the cone specified in D 217 for the penetration needle.
4. Allow no crack in the crack sealing materials or break in the bond between the sealer and the mortar blocks over 1/4 in. deep for any specimen after completion of the test.

2.9. **Asphalt-Rubber Binders**. Provide asphalt-rubber (A-R) binders that are mixtures of asphalt binder and CRM, which have been reacted at elevated temperatures. Provide A-R binders meeting D6114 and containing a minimum of 15% CRM by weight. Provide Types I or II, containing CRM Grade C, for use in hot-mixed aggregate mixtures. Provide Types II or III, containing CRM Grade B, for use in surface treatment binder. Ensure binder properties meet the requirements of Table 16.

Table 16
A-R Binders

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

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

Separation testing is not required if:

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

Table 17
Performance-Graded Binders

Property and Test Method	Performance Grade																		
	PG 58			PG 64				PG 70				PG 76				PG 82		
	-22	-28	-34	-16	-22	-28	-34	-16	-22	-28	-34	-16	-22	-28	-34	-16	-22	-28
Average 7-day max pavement design temperature, °C[1]	< 58			< 64				< 70				< 76				< 82		
Min pavement design temperature, °C[1]	>-22	>-28	>-34	>-16	>-22	>-28	>-34	>-16	>-22	>-28	>-34	>-16	>-22	>-28	>-34	>-16	>-22	>-28
Original Binder																		
Flash point, T 48, Min, °C	230																	
Viscosity, T 316:[2,3] Max, 3.0 Pa·s, test temperature, °C	135																	
Dynamic shear, T 315:[4] G*/sin(δ), Min, 1.00 kPa, Max, 2.00 kPa,[7] Test temperature @ 10 rad/sec., °C	58			64				70				76				82		
Elastic recovery, D 6084, 50°F, % Min	–	–	30	–	–	30	50	–	30	50	60	30	50	60	70	50	60	70
Rolling Thin-Film Oven (Tex-541-C)																		
Mass loss, Tex-541-C, Max, %	1.0																	
Dynamic shear, T 315: G*/sin(δ), Min, 2.20 kPa, Max, 5.00 kPa,[7] Test temperature @ 10 rad/sec., °C	58			64				70				76				82		
Pressure Aging Vessel (PAV) Residue (R 28)																		
PAV aging temperature, °C	100																	
Dynamic shear, T 315: G*sin(δ), Max, 5,000 kPa Test temperature @ 10 rad/sec., °C	25	22	19	28	25	22	19	28	25	22	19	28	25	22	19	28	25	22
Creep stiffness, T 313:[5,6] *S*, max, 300 MPa, *m*-value, Min, 0.300 Test temperature @ 60 sec., °C	-12	-18	-24	-6	-12	-18	-24	-6	-12	-18	-24	-6	-12	-18	-24	-6	-12	-18
Direct tension, T 314:[6] Failure strain, Min, 1.0% Test temperature @ 1.0 mm/min., °C	-12	-18	-24	-6	-12	-18	-24	-6	-12	-18	-24	-6	-12	-18	-24	-6	-12	-18

1. Pavement temperatures are estimated from air temperatures using an algorithm contained in a Department-supplied computer program, may be provided by the Department, or by following the procedures outlined in AASHTO MP 2 and PP 28.
2. This requirement may be waived at the Department's discretion if the supplier warrants that the asphalt binder can be adequately pumped, mixed, and compacted at temperatures that meet all applicable safety, environmental, and constructability requirements. At test temperatures where the binder is a Newtonian fluid, any suitable standard means of viscosity measurement may be used, including capillary (T 201 or T 202) or rotational viscometry (T 316).
3. Viscosity at 135°C is an indicator of mixing and compaction temperatures that can be expected in the lab and field. High values may indicate high mixing and compaction temperatures. Additionally, significant variation can occur from batch to batch. Contractors should be aware that variation could significantly impact their mixing and compaction operations. Contractors are therefore responsible for addressing any constructability issues that may arise.
4. For quality control of unmodified asphalt binder production, measurement of the viscosity of the original asphalt binder may be substituted for dynamic shear measurements of G*/sin(δ) at test temperatures where the asphalt is a Newtonian fluid. Any suitable standard means of viscosity measurement may be used, including capillary (T 201 or T 202) or rotational viscometry (T 316).
5. Silicone beam molds, as described in AASHTO TP 1-93, are acceptable for use.
6. If creep stiffness is below 300 MPa, direct tension test is not required. If creep stiffness is between 300 and 600 MPa, the direct tension failure strain requirement can be used instead of the creep stiffness requirement. The m-value requirement must be satisfied in both cases.
7. Maximum values for unaged and RTFO aged dynamic shear apply only to materials used as substitute binders, as described in specification Items 340, "Dense-Graded Hot-Mix Asphalt (Small Quantity)," 341, "Dense-Graded Hot-Mix Asphalt," and 344, "Superpave Mixtures."

3. EQUIPMENT

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

4. CONSTRUCTION

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

Table 18
Typical Material Use

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

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

Table 19
Storage and Application Temperatures

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

5. MEASUREMENT AND PAYMENT

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

Item 301
Asphalt Antistripping Agents

1. DESCRIPTION

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

2. MATERIALS

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

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

Ensure all liquid antistripping agents arrive in:

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

Provide product information to the Engineer including:

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

3. EQUIPMENT

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

4. CONSTRUCTION

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

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

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

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

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

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

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

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

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

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

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

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

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

- Handle in accordance with the manufacturer's recommendations.
- Add at the manufacturer's recommended addition temperature.
- Add into the asphalt line by means of an in-line-metering device, in accordance with Item 520, "Weighing and Measuring Equipment," and a blending device to disperse the agent.
- Place the metering and blending devices in an approved location.

5. MEASUREMENT AND PAYMENT

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

Item 302
Aggregates for Surface Treatments

1. DESCRIPTION

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

2. MATERIALS

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

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

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

Table 1
Aggregate Types

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

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

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

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

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

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

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

Table 3
Aggregate Requirements

Property	Test Method	Requirement	Remarks
Sampling	Tex-221-F	-	
SAC	AQMP	As shown on the plans	
Deleterious Material, %, Max	Tex-217-F, Part I	2.0	Not required for lightweight aggregate.
Decantation, %, Max	Tex-406-A	1.5	
Flakiness Index, Max	Tex-224-F	17	Unless otherwise shown on the plans.
Gradation	Tex-200-F, Part I	See Table 2	
Los Angeles Abrasion, %, Max	Tex-410-A	35	
Magnesium Sulfate Soundness, 5 Cycle, %, Max	Tex-411-A	25	
Micro-Deval Abrasion, %, Max	Tex-461-A	–	Not used for acceptance purposes. Used by the Engineer as an indicator for further investigation.
Coarse Aggregate Angularity, 2 Crushed Faces, %, Min	Tex-460-A, Part I	85	Unless otherwise shown on the plans. Only required for crushed gravel
Additional Requirements for Lightweight Aggregate			
Dry Loose Unit Wt., lb./cu. ft.	Tex-404-A	35–60	
Pressure Slaking, %, Max	Tex-431-A	6.0	
Freeze-Thaw Loss, %, Max	Tex-432-A	10.0	
Water Absorption, 24 hr., %, Max	Tex-433-A	12.0	Unless otherwise shown on the plans.

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

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

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

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

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

3. EQUIPMENT

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

4. CONSTRUCTION

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

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

5. MEASUREMENT AND PAYMENT

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

Item 305

Salvaging, Hauling, and Stockpiling Reclaimable Asphalt Pavement

1. DESCRIPTION

Salvage, haul, and stockpile existing asphalt material.

2. CONSTRUCTION

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

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

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

3. MEASUREMENT

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

4. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Salvaging, Hauling, and Stockpiling Reclaimable Asphalt Pavement" for cubic yard measurement, and for "Salvaging, Hauling, and Stockpiling Reclaimable Asphalt Pavement (Depth Specified)" for square yard measurement. This price is full compensation for cleaning and removing existing pavement; stockpile area preparation; loading, crushing or breaking, hauling, and stockpiling material; and material, equipment, labor, tools, supplies, and incidentals.

Item 310
Prime Coat

1. DESCRIPTION

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

2. MATERIALS

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

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

3. EQUIPMENT

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

4. CONSTRUCTION

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

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

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

4.3. **Application**.

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

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

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

5. MEASUREMENT

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

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Prime Coat" or "Prime Coat and Blotter" of the type and grade of binder specified. This price is full compensation for cleaning and sprinkling the area to be primed; materials, including blotter material; and rolling, equipment, labor, tools, and incidentals.

Item 314
Emulsified Asphalt Treatment

1. DESCRIPTION

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

2. MATERIALS

Furnish materials in accordance with the following.

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

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

3. EQUIPMENT

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

4. CONSTRUCTION

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

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

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

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

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

5. MEASUREMENT

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

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Emulsified Asphalt (Base or Subgrade Treatment)," "Emulsified Asphalt (Erosion Control)," or "Emulsified Asphalt (Prime Coat)," of the type and grade specified. This price is full compensation for materials, including emulsified asphalt and water, and for equipment, labor, tools, and incidentals.

Item 316
Seal Coat

1. DESCRIPTION

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

2. MATERIALS

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

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

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

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

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

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

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

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

3. EQUIPMENT

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

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

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

3.1.3. **Calibration**.

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

Include the following documentation on the test report:

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

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

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

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

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

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

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

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

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

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

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

4. CONSTRUCTION

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

4.7. **Rock Land and Shot**.

4.7.1. **Definitions**.

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

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

4.8. **Asphalt Placement**.

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

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

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

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

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

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

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

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

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

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

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

- 5 passes; or
- 3 passes when the asphalt material is an emulsion.

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

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

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

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

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

5. MEASUREMENT

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

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

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

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

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

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

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

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit prices bid for "Asphalt," "Aggregate," and "Loading, Hauling, and Distributing Aggregate" of the types-grades specified on the plans. These prices are full compensation for surface preparation; furnishing, preparing, hauling, and placing materials; removing existing pavement markers and excess aggregate; rolling; cleaning up stockpiles; and equipment, labor, tools, and incidentals.

Item 320
Equipment for Asphalt Concrete Pavement

1. DESCRIPTION

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

2. EQUIPMENT

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

2.1. **Production Equipment**. Provide:

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

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

2.1.1.1. **Aggregate Feed System**. Provide:

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

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

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

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

- a dryer or mixing system to agitate the aggregate during heating;

- a heating system that controls the temperature during production to prevent aggregate and asphalt binder damage;
- a heating system that completely burns fuel and leaves no residue; and
- a recording thermometer that continuously measures and records the mixture discharge temperature.

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

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

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

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

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

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

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

2.1.2. **Weigh-Batch Plants**. Provide a mixing plant that complies with Section 320.2.1.1., “Drum-Mix Plants,” except as required below.

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

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

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

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

2.1.3. **Modified Weigh-Batch Plants**. Provide a mixing plant that complies with Section 320.2.1.2., "Weigh-Batch Plants," except as specifically described below.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

2.4. **Field Laboratory**. Provide and maintain a Type D Structure (Asphalt Mix Control Laboratory) unless otherwise shown on the plans in accordance with Item 504, “Field Office and Laboratory,” and details shown on the plans.

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

3. MEASUREMENT AND PAYMENT

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

Item 330
Limestone Rock Asphalt Pavement

1. DESCRIPTION

Construct a base course, a surface course, a level-up course, or any combination of these courses of the types and grades shown on the plans using a cold-mixed material consisting of native limestone rock asphalt (LRA) aggregate, fluxing material, water, and when specified, additives and virgin aggregates.

2. MATERIALS

2.1. **LRA Mixture**. Furnish LRA according to DMS-9210, "Limestone Rock Asphalt (LRA)," of the type, grade, and Surface Aggregate Classification (SAC) shown on the plans.

2.2. **Tack Coat**. Furnish CSS-1H, SS-1H, or a performance-graded (PG) binder with a minimum high-temperature grade of PG 58 for tack coat binder in accordance with Item 300, "Asphalts, Oils, and Emulsions," unless otherwise shown on the plans or approved. Do not dilute emulsified asphalts at the terminal, in the field, or at any other location before use. Verify that emulsified asphalt proposed for use meets the minimum residual asphalt percentage specified in Item 300, "Asphalts, Oils, and Emulsions," if required.

The Engineer will obtain at least one sample of the tack coat per project and test the sample for specification compliance. The Engineer will obtain the sample from the asphalt distributor immediately before use.

3. EQUIPMENT

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

4. CONSTRUCTION

Provide quality control (QC) testing as needed to meet the requirements of this Item. The Department will perform quality assurance (QA) testing.

4.1. **Quality Control Plan (QCP)**. Develop a written QCP and submit for approval before beginning production. Follow QCP in detail. Obtain approval for changes to the QCP made during the project. The Engineer may suspend operations if the Contractor fails to comply with the QCP.

Include the following items in the QCP:

4.1.1. **Project Personnel**. For project personnel, include:

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

4.1.2. **Loading and Transporting**. For loading and transporting, include:

- type and application method for release agents, and
- truck and rail car loading procedures to avoid segregation.

4.1.3. **Placement and Compaction**. For placement and compaction, include:

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

4.2. **Stockpiling of LRA**. Provide a smooth and well-drained area, cleared of trash, weeds, and grass if storing LRA at the project site. Stockpile, handle, and load LRA in a manner that will minimize aggregate degradation and segregation. Avoid contamination and mixing of stockpiles. The Engineer may reject stockpiled materials that come in contact with the earth or other objectionable material.

4.3. **Hauling Operations**. Transport the LRA mixture to the project or delivery point in trucks or rail cars as needed. Clean all truck beds or rail cars before use to ensure mixture is not contaminated. Use a release agent on the Department's MPL to coat truck beds and inside rail cars when necessary. Waterproof tarpaulins are not required to cover loads.

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

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

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

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

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

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

4.5. **Compaction**. Furnish the type, size, and number or rollers required for compaction, as approved. Furnish at least one medium pneumatic-tire roller (minimum 12-ton weight). Use Tex-207-F, Part IV, to establish rolling patterns that achieve maximum compaction. Follow the selected rolling pattern unless changes that affect

compaction occur in the mixture or placement conditions. Establish a new rolling pattern when such changes occur. Compact the pavement to the cross-section of the finished paving mixture meeting the requirements of the plans and specifications. Operate vibratory rollers in static mode when not compacting or changing directions, or when the plan depth of the pavement mat is less than 1-1/2 in. unless otherwise directed.

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

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

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

4.6. **Irregularities**. Immediately take corrective actions if surface irregularities, including segregation, rutting, raveling, flushing, fat spots, mat slippage, color, texture, roller marks, tears, gouges, streaks, or uncoated aggregate particles are detected. The Engineer may allow placement to continue for no more than one day of production while the Contractor takes appropriate action. Suspend paving if the problem still exists after that day until it is corrected to the satisfaction of the Engineer.

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

4.7. **Ride Quality**. Use Surface Test Type A to evaluate ride quality in accordance with Item 585, “Ride Quality for Pavement Surfaces,” unless otherwise shown on the plans.

5. MEASUREMENT

LRA pavement will be measured by the ton of composite LRA pavement of the type actually used in the completed and accepted work in accordance with the plans and specifications for the project. Measure on scales in accordance with Item 520, “Weighing and Measuring Equipment.” Keep records on tare weight, gross weight, and net weight of the LRA paving mixture for each load of the same type of mixture. The Construction Division will measure and report the moisture content in accordance with Tex-212-F, Part II of the LRA paving mixture used to determine payment at the plant. All water and light hydrocarbon volatiles in the mixture measured in accordance with Tex-212-F, Part II, in excess of 6.0% by weight at the time of weighing, will be deducted from the net weight to determine the quantity for payment.

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under Article 330.5., “Measurement,” will be paid for at the unit price bid for “Limestone Rock Asphalt Pavement” of the type, grade, and SAC specified.

These prices are full compensation for surface preparation, materials including tack coat, placement, equipment, labor, tools, and incidentals.

Payment adjustment for ride quality, when required, will be determined in accordance with Item 585, “Ride Quality for Pavement Surfaces.”

Item 334
Hot-Mix Cold-Laid Asphalt Concrete Pavement

1. DESCRIPTION

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

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

2. MATERIALS

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

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

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

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

For sources not listed on the Department's BRSQC:

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

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

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

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

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

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

Table 1
Aggregate Quality Requirements

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

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

Table 2
Gradation Requirements for Fine Aggregate

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

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

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

- meets the gradation requirements in Table 3.

Table 3
Gradation Requirements for Mineral Filler

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

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

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

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

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

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

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

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

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

3. EQUIPMENT

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

4. CONSTRUCTION

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

4.1. **Mixture Design**.

4.1.1. **Design Requirements**. Use the typical weight design example given in Tex-204-F, Part I to design a paving mixture that consists of a uniform mixture of aggregate, asphalt material, primer, additives, and water, if allowed, which meets the requirements shown in Tables 4 and 5, unless otherwise shown on the plans.

Ensure that the mixture leaves the plant in a workable condition. Provide materials that remain workable in a stockpile for at least 6 mo.

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

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

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

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

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

Table 5
Laboratory Mixture Design Properties

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

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

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

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

4.2.2. **Storage and Heating of Asphalt Materials**. Provide enough asphalt material storage capacity to meet the requirements of the plant. Do not heat the asphalt binder above the temperatures specified in Item 300, "Asphalts, Oils, and Emulsions," or outside the manufacturer's recommended values. Keep all equipment used in the storage and handling of asphalt material clean at all times and operate the equipment in a manner that will prevent contamination with foreign matter.

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

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

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

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

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

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

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

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

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

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

4.5. **Compaction**. Furnish the type, size, and number of rollers required for compaction as approved. Furnish at least one medium pneumatic-tire roller (minimum 12-ton weight). Use the control strip method given in

Tex-207-F, Part IV, to establish rolling patterns that achieve maximum compaction. Follow the selected rolling pattern unless changes that affect compaction occur in the mixture or placement conditions. Establish a new rolling pattern when such changes occur. Compact the pavement to the cross-section of the finished paving mixture meeting the requirements of the plans and specifications. Operate vibratory rollers in static mode when not compacting, changing directions, or when the plan depth of the pavement mat is less than 1-1/2 in. unless otherwise directed.

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

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

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

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

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

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

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

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

Table 6
Operational Tolerances

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

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

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

4.8. **Ride Quality**. Use Surface Test Type A to evaluate ride quality in accordance with Item 585, "Ride Quality for Pavement Surfaces," unless otherwise shown on the plans.

5. MEASUREMENT

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

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

6. PAYMENT

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

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

Payment adjustment for ride quality, when required, will be determined in accordance with Item 585, "Ride Quality for Pavement Surfaces."

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

1. DESCRIPTION

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

2. MATERIALS

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

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

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

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

For sources not listed on the Department's BRSQC:

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

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

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

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

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

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

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

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

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

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

Table 1
Aggregate Quality Requirements

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

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

Table 2
Gradation Requirements for Fine Aggregate

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

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

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

Table 3
Gradation Requirements for Mineral Filler

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

The coarse RAP stockpile will contain only material retained by processing over a 3/8-in. or 1/2-in. screen unless otherwise approved. The fine RAP stockpile will contain only material passing the 3/8-in. or 1/2-in. screen unless otherwise approved. The Engineer may allow the Contractor to use an alternate to the 3/8-in.

or 1/2-in. screen to fractionate the RAP. The maximum percentages of fractionated RAP may be comprised of coarse or fine fractionated RAP or the combination of both coarse and fine fractionated RAP.

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

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

Table 4
Maximum Allowable Amounts of RAP[1]

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

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

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

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

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

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

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

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

Table 5
Allowable Substitute PG Binders and Maximum Recycled Binder Ratios

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

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

3. EQUIPMENT

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

4. CONSTRUCTION

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

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

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

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

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

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

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

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

Table 7
Reporting Schedule

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

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

4.3. **Mixture Design**.

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

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

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

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

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

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

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

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

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

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

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

Table 9
Laboratory Mixture Design Properties

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

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

Table 10
Hamburg Wheel Test Requirements

High-Temperature Binder Grade	Test Method	Minimum # of Passes @ 12.5 mm[1] Rut Depth, Tested @ 50°C
PG 64 or lower	Tex-242-F	10,000[2]
PG 70		15,000[3]
PG 76 or higher		20,000

1. When the rut depth at the required minimum number of passes is less than 3 mm, the Engineer may require the Contractor to increase the target laboratory-molded density (TGC) by 0.5% to no more than 97.5% or lower the Ndesign level (SGC) to no less than 35 gyrations.
2. May be decreased to no less than 5,000 passes when shown on the plans.
3. May be decreased to no less than 10,000 passes when shown on the plans.

4.3.2. **Job-Mix Formula Approval**. The job-mix formula (JMF) is the combined aggregate gradation, target laboratory-molded density (or Ndesign level), and target asphalt percentage used to establish target values for hot-mix production. JMF1 is the original laboratory mixture design used to produce the trial batch. When

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

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

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

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

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

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

Table 11
Operational Tolerances

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

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

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

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

4.4.1. **Storage and Heating of Materials**. Do not heat the asphalt binder above the temperatures specified in Item 300, "Asphalts, Oils, and Emulsions," or outside the manufacturer's recommended values. Provide the Engineer with daily records of asphalt binder and hot-mix asphalt discharge temperatures (in legible and discernible increments) in accordance with Item 320, "Equipment for Asphalt Concrete Pavement," unless

otherwise directed. Do not store mixture for a period long enough to affect the quality of the mixture, nor in any case longer than 12 hr. unless otherwise approved.

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

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

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

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

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

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

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

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

Table 12
Compacted Lift Thickness and Required Core Height

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

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

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

4.6.3. **Lay-Down Operations**.

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

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

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

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

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

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

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

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

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

4.8. **Production Acceptance**.

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

4.8.2. **Production Sampling**.

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

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

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

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

Table 13
Production and Placement Testing

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

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

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

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

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

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

4.9. **Placement Acceptance**.

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

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

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

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

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

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

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

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

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

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

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

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

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

4.9.6. **Ride Quality**. Use Surface Test Type A to evaluate ride quality in accordance with Item 585, "Ride Quality for Pavement Surfaces," unless otherwise shown on the plans.

5. MEASUREMENT

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

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under Article 340.5., "Measurement," will be paid for at the unit bid price for "Dense Graded Hot-Mix Asphalt (SQ)" of the mixture type, SAC, and binder specified. These prices are full compensation for surface preparation, materials including tack coat, placement, equipment, labor, tools, and incidentals.

Trial batches will not be paid for unless they are included in pavement work approved by the Department.

Payment adjustment for ride quality, if applicable, will be determined in accordance with Item 585, "Ride Quality for Pavement Surfaces."

Item 341
Dense-Graded Hot-Mix Asphalt

1. DESCRIPTION

Construct a hot-mix asphalt (HMA) pavement layer composed of a compacted, dense-graded mixture of aggregate and asphalt binder mixed hot in a mixing plant. Payment adjustments will apply to HMA placed under this specification unless the HMA is deemed exempt in accordance with Section 341.4.9.4., "Exempt Production."

2. MATERIALS

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

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

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

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

For sources not listed on the Department's BRSQC:

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

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

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

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

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

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

2.1.1.2. **Micro-Deval Abrasion**. The Engineer will perform a minimum of one Micro-Deval abrasion test in accordance with Tex-461-A for each coarse aggregate source used in the mixture design that has a Rated Source Soundness Magnesium (RSSM) loss value greater than 15 as listed in the BRSQC. The Engineer will perform testing before the start of production and may perform additional testing at any time during production. The Engineer may obtain the coarse aggregate samples from each coarse aggregate source or may require the Contractor to obtain the samples. The Engineer may waive all Micro-Deval testing based on a satisfactory test history of the same aggregate source.

The Engineer will estimate the magnesium sulfate soundness loss for each coarse aggregate source, when tested, using the following formula:

$$Mg_{est.} = (RSSM)(MD_{act.}/RSMD)$$

where:
$Mg_{est.}$ = magnesium sulfate soundness loss
$MD_{act.}$ = actual Micro-Deval percent loss
RSMD = Rated Source Micro-Deval

When the estimated magnesium sulfate soundness loss is greater than the maximum magnesium sulfate soundness loss specified, the coarse aggregate source will not be allowed for use unless otherwise approved. The Engineer will consult the Geotechnical, Soils, and Aggregates Branch of the Construction Division, and additional testing may be required before granting approval.

2.1.2. **Intermediate Aggregate**. Aggregates not meeting the definition of coarse or fine aggregate will be defined as intermediate aggregate. Supply intermediate aggregates, when used that are free from organic impurities. The Engineer may test the intermediate aggregate in accordance with Tex-408-A to verify the material is free from organic impurities. Supply intermediate aggregate from coarse aggregate sources, when used that meet the requirements shown in Table 1 unless otherwise approved.

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

2.1.3. **Fine Aggregate**. Fine aggregates consist of manufactured sands, screenings, and field sands. Fine aggregate stockpiles must meet the gradation requirements in Table 2. Supply fine aggregates that are free from organic impurities. The Engineer may test the fine aggregate in accordance with Tex-408-A to verify the

material is free from organic impurities. No more than 15% of the total aggregate may be field sand or other uncrushed fine aggregate. Use fine aggregate, with the exception of field sand, from coarse aggregate sources that meet the requirements shown in Table 1 unless otherwise approved.

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

Table 1
Aggregate Quality Requirements

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

1. Used to estimate the magnesium sulfate soundness loss in accordance with Section 341.2.1.1.2., "Micro-Deval Abrasion."
2. Only applies to crushed gravel.
3. Aggregates, without mineral filler, RAP, RAS, or additives, combined as used in the job-mix formula (JMF).

Table 2
Gradation Requirements for Fine Aggregate

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

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

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

Table 3
Gradation Requirements for Mineral Filler

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

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

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

2.5. **Tack Coat**. Furnish CSS-1H, SS-1H, or a PG binder with a minimum high-temperature grade of PG 58 for tack coat binder in accordance with Item 300, "Asphalts, Oils, and Emulsions." Specialized or preferred tack

coat materials may be allowed or required when shown on the plans. Do not dilute emulsified asphalts at the terminal, in the field, or at any other location before use.

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

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

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

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

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

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

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

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

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

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

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

unless otherwise shown on the plans. The Contractor will retain ownership of RAP generated on the project when shown on the plans.

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

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

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

Table 4
Maximum Allowable Amounts of RAP[1]

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

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

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

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

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

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

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

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

Table 5
Allowable Substitute PG Binders and Maximum Recycled Binder Ratios

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

1. Combined recycled binder from RAP and RAS.
2. Use no more than 20.0% recycled binder when using this originally specified PG binder.
3. WMA as defined in Section 341.2.6.2., "Warm Mix Asphalt (WMA)."
4. When used with WMA, this originally specified PG binder is allowed for use at the maximum recycled binder ratios shown in this table.

3. EQUIPMENT

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

4. CONSTRUCTION

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

4.1. **Certification**. Personnel certified by the Department-approved hot-mix asphalt certification program must conduct all mixture designs, sampling, and testing in accordance with Table 6. Supply the Engineer with a list of certified personnel and copies of their current certificates before beginning production and when personnel changes are made. Provide a mixture design developed and signed by a Level 2 certified specialist. Provide Level 1A certified specialists at the plant during production operations. Provide Level 1B certified specialists to conduct placement tests.

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

Test Description	Test Method	Contractor	Engineer	Level[1]
1. Aggregate and Recycled Material Testing				
Sampling	Tex-221-F	✓	✓	1A
Dry sieve	Tex-200-F, Part I	✓	✓	1A
Washed sieve	Tex-200-F, Part II	✓	✓	1A
Deleterious material	Tex-217-F, Parts I & III	✓	✓	1A
Decantation	Tex-217-F, Part II	✓	✓	1A
Los Angeles abrasion	Tex-410-A		✓	TxDOT
Magnesium sulfate soundness	Tex-411-A		✓	TxDOT
Micro-Deval abrasion	Tex-461-A		✓	2
Crushed face count	Tex-460-A	✓	✓	2
Flat and elongated particles	Tex-280-F	✓	✓	2
Linear shrinkage	Tex-107-E	✓	✓	2
Sand equivalent	Tex-203-F	✓	✓	2
Organic impurities	Tex-408-A	✓	✓	2
2. Asphalt Binder & Tack Coat Sampling				
Asphalt binder sampling	Tex-500-C, Part II	✓	✓	1A/1B
Tack coat sampling	Tex-500-C, Part III	✓	✓	1A/1B
3. Mix Design & Verification				
Design and JMF changes	Tex-204-F	✓	✓	2
Mixing	Tex-205-F	✓	✓	2
Molding (TGC)	Tex-206-F	✓	✓	1A
Molding (SGC)	Tex-241-F	✓	✓	1A
Laboratory-molded density	Tex-207-F	✓	✓	1A
VMA[2] (calculation only)	Tex-204-F	✓	✓	2
Rice gravity	Tex-227-F	✓	✓	1A
Ignition oven correction factors[3]	Tex-236-F	✓	✓	2
Indirect tensile strength	Tex-226-F	✓	✓	2
Hamburg Wheel test	Tex-242-F	✓	✓	2
Boil test	Tex-530-C	✓	✓	1A
4. Production Testing				
Selecting production random numbers	Tex-225-F, Part I		✓	1A
Mixture sampling	Tex-222-F	✓	✓	1A
Molding (TGC)	Tex-206-F	✓	✓	1A
Molding (SGC)	Tex-241-F	✓	✓	1A
Laboratory-molded density	Tex-207-F	✓	✓	1A
VMA[2] (calculation only)	Tex-204-F	✓	✓	1A
Rice gravity	Tex-227-F	✓	✓	1A
Gradation & asphalt binder content[3]	Tex-236-F	✓	✓	1A
Control charts	Tex-233-F	✓	✓	1A
Moisture content	Tex-212-F	✓	✓	1A
Hamburg Wheel test	Tex-242-F	✓	✓	2
Micro-Deval abrasion	Tex-461-A		✓	2
Boil test	Tex-530-C	✓	✓	1A
Abson recovery	Tex-211-F		✓	TxDOT
Overlay test	Tex-248-F		✓	TxDOT
Cantabro loss	Tex-245-F		✓	2
5. Placement Testing				
Selecting placement random numbers	Tex-225-F, Part II		✓	1A/1B
Trimming roadway cores	Tex-207-F	✓	✓	1A/1B
In-place air voids	Tex-207-F	✓	✓	1A/1B
Establish rolling pattern	Tex-207-F	✓		1B
Control charts	Tex-233-F	✓	✓	1A
Ride quality measurement	Tex-1001-S	✓	✓	Note 4
Segregation (density profile)	Tex-207-F, Part V	✓	✓	1B
Longitudinal joint density	Tex-207-F, Part VII	✓	✓	1B
Thermal profile	Tex-244-F	✓	✓	1B

1. Level 1A, 1B, and 2 are certification levels provided by the Hot Mix Asphalt Center certification program.
2. Voids in mineral aggregates.
3. Refer to Section 341.4.9.2.3., "Production Testing," for exceptions to using an ignition oven.
4. Profiler and operator are required to be certified at the Texas A&M Transportation Institute facility when Surface Test Type B is specified.

4.2. **Reporting and Responsibilities**. Use Department-provided templates to record and calculate all test data, including mixture design, production and placement QC/QA, control charts, thermal profiles, segregation density profiles, and longitudinal joint density. Obtain the current version of the templates at http://www.txdot.gov/inside-txdot/forms-publications/consultants-contractors/forms/site-manager.html or from the Engineer. The Engineer and the Contractor will provide any available test results to the other party when requested. The maximum allowable time for the Contractor and Engineer to exchange test data is as given in Table 7 unless otherwise approved. The Engineer and the Contractor will immediately report to the other party any test result that requires suspension of production or placement, a payment adjustment less than 1.000, or that fails to meet the specification requirements. Record and electronically submit all test results and pertinent information on Department-provided templates.

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

Table 7
Reporting Schedule

Description	Reported By	Reported To	To Be Reported Within
Production Quality Control			
Gradation[1]	Contractor	Engineer	1 working day of completion of the sublot
Asphalt binder content[1]			
Laboratory-molded density[2]			
Moisture content[3]			
Boil test[3]			
Production Quality Assurance			
Gradation[3]	Engineer	Contractor	1 working day of completion of the sublot
Asphalt binder content[3]			
Laboratory-molded density[1]			
Hamburg Wheel test[2]			
Boil test[3]			
Binder tests[2]			
Placement Quality Control			
In-place air voids[2]	Contractor	Engineer	1 working day of completion of the lot
Segregation[1]			
Longitudinal joint density[1]			
Thermal profile[1]			
Placement Quality Assurance			
In-place air voids[1]	Engineer	Contractor	1 working day of receipt of the trimmed cores for in-place air voids[4]
Segregation[2]			
Longitudinal joint density[2]			
Thermal profile[2]			
Aging ratio[2]			
Payment adjustment summary	Engineer	Contractor	2 working days of performing all required tests and receiving Contractor test data

1. These tests are required on every sublot.
2. Optional test. To be reported as soon as results become available.
3. To be performed at the frequency specified on the plans.
4. 2 days are allowed if cores cannot be dried to constant weight within 1 day.

The Engineer will use the Department-provided template to calculate all payment adjustment factors for the lot. Sublot samples may be discarded after the Engineer and Contractor sign off on the payment adjustment summary documentation for the lot.

Use the procedures described in Tex-233-F to plot the results of all quality control (QC) and quality assurance (QA) testing. Update the control charts as soon as test results for each sublot become available. Make the control charts readily accessible at the field laboratory. The Engineer may suspend production for failure to update control charts.

4.3. **Quality Control Plan (QCP)**. Develop and follow the QCP in detail. Obtain approval for changes to the QCP made during the project. The Engineer may suspend operations if the Contractor fails to comply with the QCP.

Submit a written QCP before the mandatory pre-paving meeting. Receive approval of the QCP before beginning production. Include the following items in the QCP:

4.3.1. **Project Personnel**. For project personnel, include:

- a list of individuals responsible for QC with authority to take corrective action;
- current contact information for each individual listed; and
- current copies of certification documents for individuals performing specified QC functions.

4.3.2. **Material Delivery and Storage**. For material delivery and storage, include:

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

4.3.3. **Production**. For production, include:

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

4.3.4. **Loading and Transporting**. For loading and transporting, include:

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

4.3.5. **Placement and Compaction**. For placement and compaction, include:

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

4.4. **Mixture Design**.

4.4.1. **Design Requirements**. The Contractor may design the mixture using a Texas Gyratory Compactor (TGC) or a Superpave Gyratory Compactor (SGC) unless otherwise shown on the plans. Use the dense-graded design procedure provided in Tex-204-F. Design the mixture to meet the requirements listed in Tables 1, 2, 3, 4, 5, 8, 9, and 10.

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

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

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

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

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

- the combined aggregate gradation, source, specific gravity, and percent of each material used;
- asphalt binder content and aggregate gradation of RAP and RAS stockpiles;
- the target laboratory-molded density (or Ndesign level when using the SGC);
- results of all applicable tests;
- the mixing and molding temperatures;
- the signature of the Level 2 person or persons that performed the design;
- the date the mixture design was performed; and
- a unique identification number for the mixture design.

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

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

1. Defined as maximum sieve size. No tolerance allowed.

Table 9
Laboratory Mixture Design Properties

Mixture Property	Test Method	Requirement
Target laboratory-molded density, % (TGC)	Tex-207-F	96.5[1]
Design gyrations (Ndesign for SGC)	Tex-241-F	50[2]
Indirect tensile strength (dry), psi	Tex-226-F	85–200[3]
Boil test[4]	Tex-530-C	–

1. Increase to 97.0% or 97.5% at the Contractor's discretion or when shown on the plans or specification.
2. Adjust within a range of 35–100 gyrations when shown on the plans or specification or when mutually agreed between the Engineer and Contractor.
3. The Engineer may allow the IDT strength to exceed 200 psi if the corresponding Hamburg Wheel rut depth is greater than 3.0 mm and less than 12.5 mm.
4. Used to establish baseline for comparison to production results. May be waived when approved.

Table 10
Hamburg Wheel Test Requirements

High-Temperature Binder Grade	Test Method	Minimum # of Passes @ 12.5 mm[1] Rut Depth, Tested @ 50°C
PG 64 or lower	Tex-242-F	10,000[2]
PG 70		15,000[3]
PG 76 or higher		20,000

1. When the rut depth at the required minimum number of passes is less than 3 mm, the Engineer may require the Contractor to increase the target laboratory-molded density (TGC) by 0.5% to no more than 97.5% or lower the Ndesign level (SGC) to no less than 35 gyrations.
2. May be decreased to no less than 5,000 passes when shown on the plans.
3. May be decreased to no less than 10,000 passes when shown on the plans.

4.4.2. **Job-Mix Formula Approval**. The job-mix formula (JMF) is the combined aggregate gradation, target laboratory-molded density (or Ndesign level), and target asphalt percentage used to establish target values for hot-mix production. JMF1 is the original laboratory mixture design used to produce the trial batch. When WMA is used, JMF1 may be designed and submitted to the Engineer without including the WMA additive. When WMA is used, document the additive or process used and recommended rate on the JMF1 submittal. The Engineer and the Contractor will verify JMF1 based on plant-produced mixture from the trial batch unless otherwise approved. The Engineer may accept an existing mixture design previously used on a Department project and may waive the trial batch to verify JMF1. The Department may require the Contractor to reimburse the Department for verification tests if more than 2 trial batches per design are required.

4.4.2.1. **Contractor's Responsibilities**.

4.4.2.1.1. **Providing Gyratory Compactor**. Use a TGC calibrated in accordance with Tex-914-K when electing or required to design the mixture in accordance with Tex-204-F, Part I, for molding production samples. Furnish an SGC calibrated in accordance with Tex-241-F when electing or required to design the mixture in accordance with Tex-204-F, Part IV, for molding production samples. Locate the SGC, if used, at the Engineer's field laboratory and make the SGC available to the Engineer for use in molding production samples.

4.4.2.1.2. **Gyratory Compactor Correlation Factors**. Use Tex-206-F, Part II, to perform a gyratory compactor correlation when the Engineer uses a different gyratory compactor. Apply the correlation factor to all subsequent production test results.

4.4.2.1.3. **Submitting JMF1**. Furnish a mix design report (JMF1) with representative samples of all component materials and request approval to produce the trial batch. Provide approximately 10,000 g of the design mixture if opting to have the Department perform the Hamburg Wheel test on the laboratory mixture, and request that the Department perform the test.

4.4.2.1.4. **Supplying Aggregates**. Provide approximately 40 lb. of each aggregate stockpile unless otherwise directed.

4.4.2.1.5. **Supplying Asphalt**. Provide at least 1 gal. of the asphalt material and sufficient quantities of any additives proposed for use.

4.4.2.1.6. **Ignition Oven Correction Factors**. Determine the aggregate and asphalt correction factors from the ignition oven in accordance with Tex-236-F. Provide the Engineer with split samples of the mixtures before the trial batch production, including all additives (except water), and blank samples used to determine the correction factors for the ignition oven used for QA testing during production. Correction factors established from a previously approved mixture design may be used for the current mixture design if the mixture design and ignition oven are the same as previously used, unless otherwise directed.

4.4.2.1.7. **Boil Test**. Perform the test and retain the tested sample from Tex-530-C until completion of the project or as directed. Use this sample for comparison purposes during production. The Engineer may waive the requirement for the boil test.

4.4.2.1.8. **Trial Batch Production**. Provide a plant-produced trial batch upon receiving conditional approval of JMF1 and authorization to produce a trial batch, including the WMA additive or process if applicable, for verification testing of JMF1 and development of JMF2. Produce a trial batch mixture that meets the requirements in Table 4, Table 5, and Table 11. The Engineer may accept test results from recent production of the same mixture instead of a new trial batch.

4.4.2.1.9. **Trial Batch Production Equipment**. Use only equipment and materials proposed for use on the project to produce the trial batch.

4.4.2.1.10. **Trial Batch Quantity**. Produce enough quantity of the trial batch to ensure that the mixture meets the specification requirements.

4.4.2.1.11. **Number of Trial Batches**. Produce trial batches as necessary to obtain a mixture that meets the specification requirements.

4.4.2.1.12. **Trial Batch Sampling**. Obtain a representative sample of the trial batch and split it into 3 equal portions in accordance with Tex-222-F. Label these portions as “Contractor,” “Engineer,” and “Referee.” Deliver samples to the appropriate laboratory as directed.

4.4.2.1.13. **Trial Batch Testing**. Test the trial batch to ensure the mixture produced using the proposed JMF1 meets the mixture requirements in Table 11. Ensure the trial batch mixture is also in compliance with the Hamburg Wheel requirement in Table 10. Use a Department-approved laboratory to perform the Hamburg Wheel test on the trial batch mixture or request that the Department perform the Hamburg Wheel test. The Engineer will be allowed 10 working days to provide the Contractor with Hamburg Wheel test results on the trial batch. Provide the Engineer with a copy of the trial batch test results.

4.4.2.1.14. **Development of JMF2**. Evaluate the trial batch test results after the Engineer grants full approval of JMF1 based on results from the trial batch, determine the optimum mixture proportions, and submit as JMF2. Adjust the asphalt binder content or gradation to achieve the specified target laboratory-molded density. The asphalt binder content established for JMF2 is not required to be within any tolerance of the optimum asphalt binder content established for JMF1; however, mixture produced using JMF2 must meet the voids in mineral aggregates (VMA) requirements for production shown in Table 8. If the optimum asphalt binder content for JMF2 is more than 0.5% lower than the optimum asphalt binder content for JMF1, the Engineer may perform or require the Contractor to perform Tex-226-F on Lot 1 production to confirm the indirect tensile strength does not exceed 200 psi. Verify that JMF2 meets the mixture requirements in Table 5.

4.4.2.1.15. **Mixture Production**. Use JMF2 to produce Lot 1 as described in Section 341.4.9.3.1.1., “Lot 1 Placement,” after receiving approval for JMF2 and a passing result from the Department’s or a Department-approved laboratory’s Hamburg Wheel test on the trial batch. If desired, proceed to Lot 1 production, once JMF2 is approved, at the Contractor’s risk without receiving the results from the Department’s Hamburg Wheel test on the trial batch.

Notify the Engineer if electing to proceed without Hamburg Wheel test results from the trial batch. Note that the Engineer may require up to the entire sublot of any mixture failing the Hamburg Wheel test to be removed and replaced at the Contractor's expense.

4.4.2.1.16. **Development of JMF3**. Evaluate the test results from Lot 1, determine the optimum mixture proportions, and submit as JMF3 for use in Lot 2.

4.4.2.1.17. **JMF Adjustments**. If JMF adjustments are necessary to achieve the specified requirements, make the adjustments before beginning a new lot. The adjusted JMF must:

- be provided to the Engineer in writing before the start of a new lot;
- be numbered in sequence to the previous JMF;
- meet the mixture requirements in Table 4 and Table 5;
- meet the master gradation limits shown in Table 8; and
- be within the operational tolerances of JMF2 listed in Table 11.

4.4.2.1.18. **Requesting Referee Testing**. Use referee testing, if needed, in accordance with Section 341.4.9.1., "Referee Testing," to resolve testing differences with the Engineer.

Table 11
Operational Tolerances

Description	Test Method	Allowable Difference Between Trial Batch and JMF1 Target	Allowable Difference from Current JMF Target	Allowable Difference between Contractor and Engineer[1]
Individual % retained for #8 sieve and larger	Tex-200-F or Tex-236-F	Must be Within Master Grading Limits in Table 8	±5.0[2,3]	±5.0
Individual % retained for sieves smaller than #8 and larger than #200			±3.0[2,3]	±3.0
% passing the #200 sieve			±2.0[2,3]	±1.6
Asphalt binder content, %	Tex-236-F	±0.5	±0.3[3]	±0.3
Laboratory-molded density, %	Tex-207-F	±1.0	±1.0	±1.0
In-place air voids, %		N/A	N/A	±1.0
Laboratory-molded bulk specific gravity		N/A	N/A	±0.020
VMA, %, min	Tex-204-F	Note 4	Note 4	N/A
Theoretical maximum specific (Rice) gravity	Tex-227-F	N/A	N/A	±0.020

1. Contractor may request referee testing only when values exceed these tolerances.
2. When within these tolerances, mixture production gradations may fall outside the master grading limits; however, the % passing the #200 will be considered out of tolerance when outside the master grading limits.
3. Only applies to mixture produced for Lot 1 and higher.
4. Test and verify that Table 8 requirements are met.

4.4.2.2. **Engineer's Responsibilities**.

4.4.2.2.1. **Gyratory Compactor**. For mixtures designed in accordance with Tex-204-F, Part I, the Engineer will use a Department TGC, calibrated in accordance with Tex-914-K, to mold samples for trial batch and production testing. The Engineer will make the Department TGC and the Department field laboratory available to the Contractor for molding verification samples, if requested by the Contractor.

For mixtures designed in accordance with Tex-204-F, Part IV, the Engineer will use a Department SGC, calibrated in accordance with Tex-241-F, to mold samples for laboratory mixture design verification. For molding trial batch and production specimens, the Engineer will use the Contractor-provided SGC at the field laboratory or provide and use a Department SGC at an alternate location. The Engineer will make the Contractor-provided SGC in the Department field laboratory available to the Contractor for molding verification samples.

4.4.2.2.2. **Conditional Approval of JMF1 and Authorizing Trial Batch**. The Engineer will review and verify conformance of the following information within 2 working days of receipt:

- the Contractor's mix design report (JMF1);
- the Contractor-provided Hamburg Wheel test results;
- all required materials including aggregates, asphalt, additives, and recycled materials; and

- the mixture specifications.

The Engineer will grant the Contractor conditional approval of JMF1 if the information provided on the paper copy of JMF1 indicates that the Contractor's mixture design meets the specifications. When the Contractor does not provide Hamburg Wheel test results with laboratory mixture design, 10 working days are allowed for conditional approval of JMF1. The Engineer will base full approval of JMF1 on the test results on mixture from the trial batch.

Unless waived, the Engineer will determine the Micro-Deval abrasion loss in accordance with Section 341.2.1.1.2., "Micro-Deval Abrasion." If the Engineer's test results are pending after 2 working days, conditional approval of JMF1 will still be granted within 2 working days of receiving JMF1. When the Engineer's test results become available, they will be used for specification compliance.

After conditionally approving JMF1, including either Contractor- or Department-supplied Hamburg Wheel test results, the Contractor is authorized to produce a trial batch.

4.4.2.2.3. **Hamburg Wheel Testing of JMF1**. If the Contractor requests the option to have the Department perform the Hamburg Wheel test on the laboratory mixture, the Engineer will mold samples in accordance with Tex-242-F to verify compliance with the Hamburg Wheel test requirement in Table 10.

4.4.2.2.4. **Ignition Oven Correction Factors**. The Engineer will use the split samples provided by the Contractor to determine the aggregate and asphalt correction factors for the ignition oven used for QA testing during production in accordance with Tex-236-F.

4.4.2.2.5. **Testing the Trial Batch**. Within 1 full working day, the Engineer will sample and test the trial batch to ensure that the mixture meets the requirements in Table 11. If the Contractor requests the option to have the Department perform the Hamburg Wheel test on the trial batch mixture, the Engineer will mold samples in accordance with Tex-242-F to verify compliance with the Hamburg Wheel test requirement in Table 10.

The Engineer will have the option to perform the following tests on the trial batch:

- Tex-226-F, to verify that the indirect tensile strength meets the requirement shown in Table 9; and
- Tex-530-C, to retain and use for comparison purposes during production.

4.4.2.2.6. **Full Approval of JMF1**. The Engineer will grant full approval of JMF1 and authorize the Contractor to proceed with developing JMF2 if the Engineer's results for the trial batch meet the requirements in Table 11. The Engineer will notify the Contractor that an additional trial batch is required if the trial batch does not meet these requirements.

4.4.2.2.7. **Approval of JMF2**. The Engineer will approve JMF2 within one working day if the mixture meets the requirements in Table 5 and the gradation meets the master grading limits shown in Table 8. The asphalt binder content established for JMF2 is not required to be within any tolerance of the optimum asphalt binder content established for JMF1; however, mixture produced using JMF2 must meet the VMA requirements shown in Table 8. If the optimum asphalt binder content for JMF2 is more than 0.5% lower than the optimum asphalt binder content for JMF1, the Engineer may perform or require the Contractor to perform Tex-226-F on Lot 1 production to confirm the indirect tensile strength does not exceed 200 psi.

4.4.2.2.8. **Approval of Lot 1 Production**. The Engineer will authorize the Contractor to proceed with Lot 1 production (using JMF2) as soon as a passing result is achieved from the Department's or a Department-approved laboratory's Hamburg Wheel test on the trial batch. The Contractor may proceed at its own risk with Lot 1 production without the results from the Hamburg Wheel test on the trial batch.

If the Department's or Department-approved laboratory's sample from the trial batch fails the Hamburg Wheel test, the Engineer will suspend production until further Hamburg Wheel tests meet the specified values. The Engineer may require up to the entire sublot of any mixture failing the Hamburg Wheel test be removed and replaced at the Contractor's expense.

4.4.2.2.9. **Approval of JMF3 and Subsequent JMF Changes**. JMF3 and subsequent JMF changes are approved if they meet the mixture requirements shown in Table 4, Table 5, and the master grading limits shown in Table 8, and are within the operational tolerances of JMF2 shown in Table 11.

4.5. **Production Operations**. Perform a new trial batch when the plant or plant location is changed. Take corrective action and receive approval to proceed after any production suspension for noncompliance to the specification. Submit a new mix design and perform a new trial batch when the asphalt binder content of:

- any RAP stockpile used in the mix is more than 0.5% higher than the value shown on the mixture design report; or
- RAS stockpile used in the mix is more than 2.0% higher than the value shown on the mixture design report.

4.5.1. **Storage and Heating of Materials**. Do not heat the asphalt binder above the temperatures specified in Item 300, "Asphalts, Oils, and Emulsions," or outside the manufacturer's recommended values. Provide the Engineer with daily records of asphalt binder and hot-mix asphalt discharge temperatures (in legible and discernible increments) in accordance with Item 320, "Equipment for Asphalt Concrete Pavement," unless otherwise directed. Do not store mixture for a period long enough to affect the quality of the mixture, nor in any case longer than 12 hr. unless otherwise approved.

4.5.2. **Mixing and Discharge of Materials**. Notify the Engineer of the target discharge temperature and produce the mixture within 25°F of the target. Monitor the temperature of the material in the truck before shipping to ensure that it does not exceed 350°F (or 275°F for WMA) and is not lower than 215°F. The Department will not pay for or allow placement of any mixture produced above 350°F.

Produce WMA within the target discharge temperature range of 215°F and 275°F when WMA is required. Take corrective action any time the discharge temperature of the WMA exceeds the target discharge range. The Engineer may suspend production operations if the Contractor's corrective action is not successful at controlling the production temperature within the target discharge range. Note that when WMA is produced, it may be necessary to adjust burners to ensure complete combustion such that no burner fuel residue remains in the mixture.

Control the mixing time and temperature so that substantially all moisture is removed from the mixture before discharging from the plant. Determine the moisture content, if requested, by oven-drying in accordance with Tex-212-F, Part II, and verify that the mixture contains no more than 0.2% of moisture by weight. Obtain the sample immediately after discharging the mixture into the truck, and perform the test promptly.

4.6. **Hauling Operations**. Clean all truck beds before use to ensure that mixture is not contaminated. Use a release agent shown on the Department's MPL to coat the inside bed of the truck when necessary.

Use equipment for hauling as defined in Section 341.4.7.3.3., "Hauling Equipment." Use other hauling equipment only when allowed.

4.7. **Placement Operations**. Collect haul tickets from each load of mixture delivered to the project and provide the Department's copy to the Engineer approximately every hour, or as directed. Use a hand-held thermal camera or infrared thermometer, when a thermal imaging system is not used, to measure and record the internal temperature of the mixture as discharged from the truck or Material Transfer Device (MTD) before or as the mix enters the paver and an approximate station number or GPS coordinates on each ticket. Calculate the daily yield and cumulative yield for the specified lift and provide to the Engineer at the end of paving operations for each day unless otherwise directed. The Engineer may suspend production if the Contractor fails to produce and provide haul tickets and yield calculations by the end of paving operations for each day.

Prepare the surface by removing raised pavement markers and objectionable material such as moisture, dirt, sand, leaves, and other loose impediments from the surface before placing mixture. Remove vegetation from pavement edges. Place the mixture to meet the typical section requirements and produce a smooth, finished surface with a uniform appearance and texture. Offset longitudinal joints of successive courses of hot-mix by at least 6 in. Place mixture so that longitudinal joints on the surface course coincide with lane lines, or as

directed. Ensure that all finished surfaces will drain properly. Place the mixture at the rate or thickness shown on the plans. The Engineer will use the guidelines in Table 12 to determine the compacted lift thickness of each layer when multiple lifts are required. The thickness determined is based on the rate of 110 lb./sq. yd. for each inch of pavement unless otherwise shown on the plans.

Table 12
Compacted Lift Thickness and Required Core Height

Mixture Type	Compacted Lift Thickness Guidelines		Minimum Untrimmed Core Height (in.) Eligible for Testing
	Minimum (in.)	Maximum (in.)	
A	3.00	6.00	2.00
B	2.50	5.00	1.75
C	2.00	4.00	1.50
D	1.50	3.00	1.25
F	1.25	2.50	1.25

4.7.1. **Weather Conditions**.

4.7.1.1. **When Using a Thermal Imaging System**. The Contractor may pave any time the roadway is dry and the roadway surface temperature is at least 32°F; however, the Engineer may restrict the Contractor from paving surface mixtures if the ambient temperature is likely to drop below 32°F within 12 hr. of paving. Provide output data from the thermal imaging system to demonstrate to the Engineer that no recurring severe thermal segregation exists in accordance with Section 341.4.7.3.1.2., "Thermal Imaging System."

4.7.1.2. **When Not Using a Thermal Imaging System**. Place mixture when the roadway surface temperature is at or above the temperatures listed in Table 13 unless otherwise approved or as shown on the plans. Measure the roadway surface temperature with a hand-held thermal camera or infrared thermometer. The Engineer may allow mixture placement to begin before the roadway surface reaches the required temperature if conditions are such that the roadway surface will reach the required temperature within 2 hr. of beginning placement operations. Place mixtures only when weather conditions and moisture conditions of the roadway surface are suitable as determined by the Engineer. The Engineer may restrict the Contractor from paving if the ambient temperature is likely to drop below 32°F within 12 hr. of paving.

Table 13
Minimum Pavement Surface Temperatures

Originally Specified High Temperature Binder Grade	Minimum Pavement Surface Temperatures (°F)	
	Subsurface Layers or Night Paving Operations	Surface Layers Placed in Daylight Operations
PG 64 or lower	45	50
PG 70	55[1]	60[1]
PG 76 or higher	60[1]	60[1]

1. Contractors may pave at temperatures 10°F lower than these values when utilizing a paving process including WMA or equipment that eliminates thermal segregation. In such cases, use a hand-held thermal camera operated in accordance with Tex-244-F to demonstrate to the satisfaction of the Engineer that the uncompacted mat has no more than 10°F of thermal segregation.

4.7.2. **Tack Coat**. Clean the surface before placing the tack coat. The Engineer will set the rate between 0.04 and 0.10 gal. of residual asphalt per square yard of surface area. Apply a uniform tack coat at the specified rate unless otherwise directed. Apply the tack coat in a uniform manner to avoid streaks and other irregular patterns. Apply a thin, uniform tack coat to all contact surfaces of curbs, structures, and all joints. Allow adequate time for emulsion to break completely before placing any material. Prevent splattering of tack coat when placed adjacent to curb, gutter, and structures. Roll the tack coat with a pneumatic-tire roller to remove streaks and other irregular patterns when directed.

4.7.3. **Lay-Down Operations**.

4.7.3.1. **Thermal Profile**. Use a hand-held thermal camera or a thermal imaging system to obtain a continuous thermal profile in accordance with Tex-244-F. Thermal profiles are not applicable in areas described in Section 341.4.9.3.1.4., "Miscellaneous Areas."

4.7.3.1.1. **Thermal Segregation**.

4.7.3.1.1.1. **Moderate**. Any areas that have a temperature differential greater than 25°F, but not exceeding 50°F, are deemed as having moderate thermal segregation.

4.7.3.1.1.2. **Severe**. Any areas that have a temperature differential greater than 50°F are deemed as having severe thermal segregation.

4.7.3.1.2. **Thermal Imaging System**. Review the output results when a thermal imaging system is used, and provide the automated report described in Tex-244-F to the Engineer daily unless otherwise directed. Modify the paving process as necessary to eliminate any recurring (moderate or severe) thermal segregation identified by the thermal imaging system. The Engineer may suspend paving operations if the Contractor cannot successfully modify the paving process to eliminate recurring severe thermal segregation. Density profiles are not required and not applicable when using a thermal imaging system. Provide the Engineer with electronic copies of all daily data files that can be used with the thermal imaging system software to generate temperature profile plots upon completion of the project or as requested by the Engineer.

4.7.3.1.3. **Thermal Camera**. Take immediate corrective action to eliminate recurring moderate thermal segregation when a hand-held thermal camera is used. Evaluate areas with moderate thermal segregation by performing density profiles in accordance with Section 341.4.9.3.3.2., "Segregation (Density Profile)." Provide the Engineer with the thermal profile of every sublot within one working day of the completion of each lot. Report the results of each thermal profile in accordance with Section 341.4.2., "Reporting and Responsibilities." The Engineer will use a hand-held thermal camera to obtain a thermal profile at least once per project. No production or placement payment adjustments greater than 1.000 will be paid for any sublot that contains severe thermal segregation. Suspend operations and take immediate corrective action to eliminate severe thermal segregation unless otherwise directed. Resume operations when the Engineer determines that subsequent production will meet the requirements of this Section. Evaluate areas with severe thermal segregation by performing density profiles in accordance with Section 341.4.9.3.3.2., "Segregation (Density Profile)." Remove and replace the material in any areas that have both severe thermal segregation and a failing result for Segregation (Density Profile) unless otherwise directed. The sublot in question may receive a production and placement payment adjustment greater than 1.000, if applicable, when the defective material is successfully removed and replaced.

4.7.3.2. **Windrow Operations**. Operate windrow pickup equipment so that when hot-mix is placed in windrows, substantially all the mixture deposited on the roadbed is picked up and loaded into the paver.

4.7.3.3. **Hauling Equipment**. Use belly dumps, live bottom, or end dump trucks to haul and transfer mixture; however, with exception of paving miscellaneous areas, end dump trucks are only allowed when used in conjunction with an MTD with remixing capability or when a thermal imaging system is used unless otherwise allowed.

4.7.3.4. **Screed Heaters**. Turn off screed heaters to prevent overheating of the mat if the paver stops for more than 5 min. The Engineer may evaluate the suspect area in accordance with Section 341.4.9.3.3.4., "Recovered Asphalt Dynamic Shear Rheometer (DSR)," if the screed heater remains on for more than 5 min. while the paver is stopped.

4.8. **Compaction**. Compact the pavement uniformly to contain between 3.8% and 8.5% in-place air voids. Take immediate corrective action to bring the operation within 3.8% and 8.5% when the in-place air voids exceed the range of these tolerances. The Engineer will allow paving to resume when the proposed corrective action is likely to yield between 3.8% and 8.5% in-place air voids.

Obtain cores in areas placed under Exempt Production, as directed, at locations determined by the Engineer. The Engineer may test these cores and suspend operations or require removal and replacement if the in-place air voids are less than 2.7% or more than 9.9%. Areas defined in Section 341.4.9.3.1.4., "Miscellaneous Areas," are not subject to in-place air void determination.

Furnish the type, size, and number of rollers required for compaction as approved. Use a pneumatic-tire roller to seal the surface unless excessive pickup of fines occurs. Use additional rollers as required to

remove any roller marks. Use only water or an approved release agent on rollers, tamps, and other compaction equipment unless otherwise directed.

Use the control strip method shown in Tex-207-F, Part IV, on the first day of production to establish the rolling pattern that will produce the desired in-place air voids unless otherwise directed.

Use tamps to thoroughly compact the edges of the pavement along curbs, headers, and similar structures and in locations that will not allow thorough compaction with rollers. The Engineer may require rolling with a trench roller on widened areas, in trenches, and in other limited areas.

Complete all compaction operations before the pavement temperature drops below 160°F unless otherwise allowed. The Engineer may allow compaction with a light finish roller operated in static mode for pavement temperatures below 160°F.

Allow the compacted pavement to cool to 160°F or lower before opening to traffic unless otherwise directed. Sprinkle the finished mat with water or limewater, when directed, to expedite opening the roadway to traffic.

4.9. **Acceptance Plan**. Payment adjustments for the material will be in accordance with Article 341.6., "Payment."

Sample and test the hot-mix on a lot and sublot basis. Suspend production until test results or other information indicates to the satisfaction of the Engineer that the next material produced or placed will result in payment factors of at least 1.000, if the production payment factor given in Section 341.6.1., "Production Payment Adjustment Factors," for 2 consecutive lots or the placement pay factor given in Section 341.6.2., "Placement Payment Adjustment Factors," for 2 consecutive lots is below 1.000.

4.9.1. **Referee Testing**. The Construction Division is the referee laboratory. The Contractor may request referee testing if a "remove and replace" condition is determined based on the Engineer's test results, or if the differences between Contractor and Engineer test results exceed the maximum allowable difference shown in Table 11 and the differences cannot be resolved. The Contractor may also request referee testing if the Engineer's test results require suspension of production and the Contractor's test results are within specification limits. Make the request within 5 working days after receiving test results and cores from the Engineer. Referee tests will be performed only on the sublot in question and only for the particular tests in question. Allow 10 working days from the time the referee laboratory receives the samples for test results to be reported. The Department may require the Contractor to reimburse the Department for referee tests if more than 3 referee tests per project are required and the Engineer's test results are closer to the referee test results than the Contractor's test results.

The Construction Division will determine the laboratory-molded density based on the molded specific gravity and the maximum theoretical specific gravity of the referee sample. The in-place air voids will be determined based on the bulk specific gravity of the cores, as determined by the referee laboratory and the Engineer's average maximum theoretical specific gravity for the lot. With the exception of "remove and replace" conditions, referee test results are final and will establish payment adjustment factors for the sublot in question. The Contractor may decline referee testing and accept the Engineer's test results when the placement payment adjustment factor for any sublot results in a "remove and replace" condition. Placement sublots subject to be removed and replaced will be further evaluated in accordance with Section 341.6.2.2., "Placement Sublots Subject to Removal and Replacement."

4.9.2. **Production Acceptance**.

4.9.2.1. **Production Lot**. A production lot consists of 4 equal sublots. The default quantity for Lot 1 is 1,000 tons; however, when requested by the Contractor, the Engineer may increase the quantity for Lot 1 to no more than 4,000 tons. The Engineer will select subsequent lot sizes based on the anticipated daily production such that approximately 3 to 4 sublots are produced each day. The lot size will be between 1,000 tons and 4,000 tons. The Engineer may change the lot size before the Contractor begins any lot.

If the optimum asphalt binder content for JMF2 is more than 0.5% lower than the optimum asphalt binder content for JMF1, the Engineer may perform or require the Contractor to perform Tex-226-F on Lot 1 to confirm the indirect tensile strength does not exceed 200 psi. Take corrective action to bring the mixture within specification compliance if the indirect tensile strength exceeds 200 psi unless otherwise directed.

4.9.2.1.1. **Incomplete Production Lots**. If a lot is begun but cannot be completed, such as on the last day of production or in other circumstances deemed appropriate, the Engineer may close the lot. Adjust the payment for the incomplete lot in accordance with Section 341.6.1., "Production Payment Adjustment Factors." Close all lots within 5 working days unless otherwise allowed.

4.9.2.2. **Production Sampling**.

4.9.2.2.1. **Mixture Sampling**. Obtain hot-mix samples from trucks at the plant in accordance with Tex-222-F. The sampler will split each sample into 3 equal portions in accordance with Tex-200-F and label these portions as "Contractor," "Engineer," and "Referee." The Engineer will perform or witness the sample splitting and take immediate possession of the samples labeled "Engineer" and "Referee." The Engineer will maintain the custody of the samples labeled "Engineer" and "Referee" until the Department's testing is completed.

4.9.2.2.1.1. **Random Sample**. At the beginning of the project, the Engineer will select random numbers for all production sublots. Determine sample locations in accordance with Tex-225-F. Take one sample for each sublot at the randomly selected location. The Engineer will perform or witness the sampling of production sublots.

4.9.2.2.1.2. **Blind Sample**. For one sublot per lot, the Engineer will obtain and test a "blind" sample instead of the random sample collected by the Contractor. Test either the "blind" or the random sample; however, referee testing (if applicable) will be based on a comparison of results from the "blind" sample. The location of the Engineer's "blind" sample will not be disclosed to the Contractor. The Engineer's "blind" sample may be randomly selected in accordance with Tex-225-F for any sublot or selected at the discretion of the Engineer. The Engineer will use the Contractor's split sample for sublots not sampled by the Engineer.

4.9.2.2.2. **Informational Cantabro and Overlay Testing**. When requested or shown on the plans, select one random sublot from Lot 2 or higher for Cantabro and Overlay testing during the first week of production. Obtain and provide the Engineer with approximately 90 lb. (40 kg) of mixture in sealed containers, boxes, or bags labeled with the Control-Section-Job (CSJ), mixture type, lot, and sublot number. The Engineer will ship the mixture to the Construction Division for Cantabro and Overlay testing. Results from these tests will not be used for specification compliance.

4.9.2.2.3. **Asphalt Binder Sampling**. Obtain a 1-qt. sample of the asphalt binder for each lot of mixture produced. Obtain the sample at approximately the same time the mixture random sample is obtained. Sample from a port located immediately upstream from the mixing drum or pug mill in accordance with Tex-500-C, Part II. Label the can with the corresponding lot and sublot numbers and deliver the sample to the Engineer. The Engineer may also obtain independent samples. If obtaining an independent asphalt binder sample, the Engineer will split a sample of the asphalt binder with the Contractor. The Engineer will test at least one asphalt binder sample per project to verify compliance with Item 300, "Asphalts, Oils, and Emulsions."

4.9.2.3. **Production Testing**. The Contractor and Engineer must perform production tests in accordance with Table 14. The Contractor has the option to verify the Engineer's test results on split samples provided by the Engineer. Determine compliance with operational tolerances listed in Table 11 for all sublots.

Take immediate corrective action if the Engineer's laboratory-molded density on any sublot is less than 95.0% or greater than 98.0% to bring the mixture within these tolerances. The Engineer may suspend operations if the Contractor's corrective actions do not produce acceptable results. The Engineer will allow production to resume when the proposed corrective action is likely to yield acceptable results.

The Engineer may allow alternate methods for determining the asphalt binder content and aggregate gradation if the aggregate mineralogy is such that Tex-236-F does not yield reliable results. Provide evidence that results from Tex-236-F are not reliable before requesting permission to use an alternate method unless otherwise directed. Use the applicable test procedure as directed if an alternate test method is allowed.

Table 14
Production and Placement Testing Frequency

Description	Test Method	Minimum Contractor Testing Frequency	Minimum Engineer Testing Frequency
Individual % retained for #8 sieve and larger	Tex-200-F or Tex-236-F	1 per sublot	1 per 12 sublots[1]
Individual % retained for sieves smaller than #8 and larger than #200			
% passing the #200 sieve			
Laboratory-molded density	Tex-207-F	N/A	1 per sublot[1]
Laboratory-molded bulk specific gravity			
In-place air voids			
VMA	Tex-204-F		
Segregation (density profile)[2]	Tex-207-F, Part V	1 per sublot	1 per project
Longitudinal joint density	Tex-207-F, Part VII		
Moisture content	Tex-212-F, Part II	When directed	
Theoretical maximum specific (Rice) gravity	Tex-227-F	N/A	1 per sublot[1]
Asphalt binder content	Tex-236-F	1 per sublot	1 per lot[1]
Hamburg Wheel test	Tex-242-F	N/A	1 per project
Recycled Asphalt Shingles (RAS)[3]	Tex-217-F, Part III	N/A	
Thermal profile[2]	Tex-244-F	1 per sublot	
Asphalt binder sampling and testing	Tex-500-C	1 per lot (sample only)	
Tack coat sampling and testing	Tex-500-C, Part III	N/A	
Boil test[4]	Tex-530-C	1 per lot	
Cantabro loss[5]	Tex-245-F	1 per project (sample only)	
Overlay test[5]	Tex-248-F		

1. For production defined in Section 341.4.9.4., "Exempt Production," the Engineer will test one per day if 100 tons or more are produced. For Exempt Production, no testing is required when less than 100 tons are produced.
2. Not required when a thermal imaging system is used.
3. Testing performed by the Construction Division or designated laboratory.
4. The Engineer may reduce or waive the sampling and testing requirements based on a satisfactory test history.
5. Testing performed by the Construction Division and for informational purposes only.

4.9.2.4. **Operational Tolerances**. Control the production process within the operational tolerances listed in Table 11. When production is suspended, the Engineer will allow production to resume when test results or other information indicates the next mixture produced will be within the operational tolerances.

4.9.2.4.1. **Gradation**. Suspend operation and take corrective action if any aggregate is retained on the maximum sieve size shown in Table 8. A sublot is defined as out of tolerance if either the Engineer's or the Contractor's test results are out of operational tolerance. Suspend production when test results for gradation exceed the operational tolerances for 3 consecutive sublots on the same sieve or 4 consecutive sublots on any sieve unless otherwise directed. The consecutive sublots may be from more than one lot.

4.9.2.4.2. **Asphalt Binder Content**. A sublot is defined as out of operational tolerance if either the Engineer's or the Contractor's test results exceed the values listed in Table 11. No production or placement payment adjustments greater than 1.000 will be paid for any sublot that is out of operational tolerance for asphalt binder content. Suspend production and shipment of the mixture if the Engineer's or the Contractor's asphalt binder content deviates from the current JMF by more than 0.5% for any sublot.

4.9.2.4.3. **Voids in Mineral Aggregates (VMA)**. The Engineer will determine the VMA for every sublot. For sublots when the Engineer does not determine asphalt binder content, the Engineer will use the asphalt binder content results from QC testing performed by the Contractor to determine VMA.

Take immediate corrective action if the VMA value for any sublot is less than the minimum VMA requirement for production listed in Table 8. Suspend production and shipment of the mixture if the Engineer's VMA results on 2 consecutive sublots are below the minimum VMA requirement for production listed in Table 8. No production or placement payment adjustments greater than 1.000 will be paid for any sublot that does not meet the minimum VMA requirement for production listed in Table 8 based on the Engineer's VMA determination.

Suspend production and shipment of the mixture if the Engineer's VMA result is more than 0.5% below the minimum VMA requirement for production listed in Table 8. In addition to suspending production, the Engineer may require removal and replacement or may allow the sublot to be left in place without payment.

4.9.2.4.4. **Hamburg Wheel Test**. The Engineer may perform a Hamburg Wheel test at any time during production, including when the boil test indicates a change in quality from the materials submitted for JMF1. In addition to testing production samples, the Engineer may obtain cores and perform Hamburg Wheel tests on any areas of the roadway where rutting is observed. Suspend production until further Hamburg Wheel tests meet the specified values when the production or core samples fail the Hamburg Wheel test criteria in Table 10. Core samples, if taken, will be obtained from the center of the finished mat or other areas excluding the vehicle wheel paths. The Engineer may require up to the entire sublot of any mixture failing the Hamburg Wheel test to be removed and replaced at the Contractor's expense.

If the Department's or Department approved laboratory's Hamburg Wheel test results in a "remove and replace" condition, the Contractor may request that the Department confirm the results by re-testing the failing material. The Construction Division will perform the Hamburg Wheel tests and determine the final disposition of the material in question based on the Department's test results.

4.9.2.5. **Individual Loads of Hot-Mix**. The Engineer can reject individual truckloads of hot-mix. When a load of hot-mix is rejected for reasons other than temperature, contamination, or excessive uncoated particles, the Contractor may request that the rejected load be tested. Make this request within 4 hr. of rejection. The Engineer will sample and test the mixture. If test results are within the operational tolerances shown in Table 11, payment will be made for the load. If test results are not within operational tolerances, no payment will be made for the load.

4.9.3. **Placement Acceptance**.

4.9.3.1. **Placement Lot**. A placement lot consists of 4 placement sublots. A placement sublot consists of the area placed during a production sublot.

4.9.3.1.1. **Lot 1 Placement**. Placement payment adjustments greater than 1.000 for Lot 1 will be in accordance with Section 341.6.2., "Placement Payment Adjustment Factors"; however, no placement adjustment less than 1.000 will be assessed for any sublot placed in Lot 1 when the in-place air voids are greater than or equal to 2.7% and less than or equal to 9.9%. Remove and replace any sublot with in-place air voids less than 2.7% or greater than 9.9%.

4.9.3.1.2. **Incomplete Placement Lots**. An incomplete placement lot consists of the area placed as described in Section 341.4.9.2.1.1., "Incomplete Production Lots," excluding areas defined in Section 341.4.9.3.1.4., "Miscellaneous Areas." Placement sampling is required if the random sample plan for production resulted in a sample being obtained from an incomplete production sublot.

4.9.3.1.3. **Shoulders, Ramps, Etc**. Shoulders, ramps, intersections, acceleration lanes, deceleration lanes, and turn lanes are subject to in-place air void determination and payment adjustments unless designated on the plans as not eligible for in-place air void determination. Intersections may be considered miscellaneous areas when determined by the Engineer.

4.9.3.1.4. **Miscellaneous Areas**. Miscellaneous areas include areas that typically involve significant handwork or discontinuous paving operations, such as temporary detours, driveways, mailbox turnouts, crossovers, gores, spot level-up areas, and other similar areas. Temporary detours are subject to in-place air void determination when shown on the plans. Miscellaneous areas also include level-ups and thin overlays when the layer thickness specified on the plans is less than the minimum untrimmed core height eligible for testing shown in Table 12. The specified layer thickness is based on the rate of 110 lb./sq. yd. for each inch of pavement unless another rate is shown on the plans. When "level up" is listed as part of the item bid description code, a payment adjustment factor of 1.000 will be assigned for all placement sublots as described in Article 341.6, "Payment." Miscellaneous areas are not eligible for random placement sampling locations. Compact miscellaneous areas in accordance with Section 341.4.8., "Compaction." Miscellaneous

areas are not subject to in-place air void determination, thermal profiles testing, segregation (density profiles), or longitudinal joint density evaluations.

4.9.3.2. **Placement Sampling**. The Engineer will select random numbers for all placement sublots at the beginning of the project. The Engineer will provide the Contractor with the placement random numbers immediately after the sublot is completed. Mark the roadway location at the completion of each sublot and record the station number. Determine one random sample location for each placement sublot in accordance with Tex-225-F. Adjust the random sample location by no more than necessary to achieve a 2-ft. clearance if the location is within 2 ft. of a joint or pavement edge.

Shoulders, ramps, intersections, acceleration lanes, deceleration lanes, and turn lanes are always eligible for selection as a random sample location; however, if a random sample location falls on one of these areas and the area is designated on the plans as not subject to in-place air void determination, cores will not be taken for the sublot and a 1.000 pay factor will be assigned to that sublot.

Provide the equipment and means to obtain and trim roadway cores on site. On-site is defined as in close proximity to where the cores are taken. Obtain the cores within one working day of the time the placement sublot is completed unless otherwise approved. Obtain two 6-in. diameter cores side-by-side from within 1 ft. of the random location provided for the placement sublot. For Type D and Type F mixtures, 4-in. diameter cores are allowed. Mark the cores for identification, measure and record the untrimmed core height, and provide the information to the Engineer. The Engineer will witness the coring operation and measurement of the core thickness. Visually inspect each core and verify that the current paving layer is bonded to the underlying layer. Take corrective action if an adequate bond does not exist between the current and underlying layer to ensure that an adequate bond will be achieved during subsequent placement operations.

Trim the cores immediately after obtaining the cores from the roadway in accordance with Tex-207-F if the core heights meet the minimum untrimmed value listed in Table 12. Trim the cores on site in the presence of the Engineer. Use a permanent marker or paint pen to record the lot and sublot numbers on each core as well as the designation as Core A or B. The Engineer may require additional information to be marked on the core and may choose to sign or initial the core. The Engineer will take custody of the cores immediately after they are trimmed and will retain custody of the cores until the Department's testing is completed. Before turning the trimmed cores over to the Engineer, the Contractor may wrap the trimmed cores or secure them in a manner that will reduce the risk of possible damage occurring during transport by the Engineer. After testing, the Engineer will return the cores to the Contractor.

The Engineer may have the cores transported back to the Department's laboratory at the HMA plant via the Contractor's haul truck or other designated vehicle. In such cases where the cores will be out of the Engineer's possession during transport, the Engineer will use Department-provided security bags and the Roadway Core Custody protocol located at http://www.txdot.gov/business/specifications.htm to provide a secure means and process that protects the integrity of the cores during transport.

Decide whether to include the pair of cores in the air void determination for that sublot if the core height before trimming is less than the minimum untrimmed value shown in Table 12. Trim the cores as described above before delivering to the Engineer if electing to have the cores included in the air void determination. Deliver untrimmed cores to the Engineer and inform the Engineer of the decision to not have the cores included in air void determination if electing to not have the cores included in air void determination. The placement pay factor for the sublot will be 1.000 if cores will not be included in air void determination.

Instead of the Contractor trimming the cores on site immediately after coring, the Engineer and the Contractor may mutually agree to have the trimming operations performed at an alternate location such as a field laboratory or other similar location. In such cases, the Engineer will take possession of the cores immediately after they are obtained from the roadway and will retain custody of the cores until testing is completed. Either the Department or Contractor representative may perform trimming of the cores. The Engineer will witness all trimming operations in cases where the Contractor representative performs the trimming operation.

Dry the core holes and tack the sides and bottom immediately after obtaining the cores. Fill the hole with the same type of mixture and properly compact the mixture. Repair core holes with other methods when approved.

4.9.3.3. **Placement Testing**. Perform placement tests in accordance with Table 14. After the Engineer returns the cores, the Contractor may test the cores to verify the Engineer's test results for in-place air voids. The allowable differences between the Contractor's and Engineer's test results are listed in Table 11.

4.9.3.3.1. **In-Place Air Voids**. The Engineer will measure in-place air voids in accordance with Tex-207-F and Tex-227-F. Before drying to a constant weight, cores may be pre-dried using a Corelok or similar vacuum device to remove excess moisture. The Engineer will average the values obtained for all sublots in the production lot to determine the theoretical maximum specific gravity. The Engineer will use the average air void content for in-place air voids.

The Engineer will use the vacuum method to seal the core if required by Tex-207-F. The Engineer will use the test results from the unsealed core to determine the placement payment adjustment factor if the sealed core yields a higher specific gravity than the unsealed core. After determining the in-place air void content, the Engineer will return the cores and provide test results to the Contractor.

4.9.3.3.2. **Segregation (Density Profile)**. Test for segregation using density profiles in accordance with Tex-207-F, Part V. Density profiles are not required and are not applicable when using a thermal imaging system. Density profiles are not applicable in areas described in Section 341.4.9.3.1.4., "Miscellaneous Areas."

Perform a density profile every time the paver stops for more than 60 sec. on areas that are identified by either the Contractor or the Engineer as having thermal segregation and on any visibly segregated areas unless otherwise approved. Perform a minimum of one profile per sublot if the paver does not stop for more than 60 sec. and there are no visibly segregated areas or areas that are identified as having thermal segregation.

Provide the Engineer with the density profile of every sublot in the lot within one working day of the completion of each lot. Report the results of each density profile in accordance with Section 341.4.2., "Reporting and Responsibilities."

The density profile is considered failing if it exceeds the tolerances in Table 15. No production or placement payment adjustments greater than 1.000 will be paid for any sublot that contains a failing density profile. When a hand-held thermal camera is used instead of a thermal imaging system, the Engineer will measure the density profile at least once per project. The Engineer's density profile results will be used when available. The Engineer may require the Contractor to remove and replace the area in question if the area fails the density profile and has surface irregularities as defined in Section 341.4.9.3.3.5., "Irregularities." The sublot in question may receive a production and placement payment adjustment greater than 1.000, if applicable, when the defective material is successfully removed and replaced.

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 15
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

4.9.3.3.3. **Longitudinal Joint Density**.

4.9.3.3.3.1. **Informational Tests**. Perform joint density evaluations while establishing the rolling pattern and verify that the joint density is no more than 3.0 pcf 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 sublot, unless otherwise directed.

4.9.3.3.3.2. **Record Tests**. Perform a joint density evaluation for each sublot at each pavement edge that is or will become a longitudinal joint. Joint density evaluations are not applicable in areas described in Section 341.4.9.3.1.4., "Miscellaneous Areas." Determine the joint density in accordance with Tex-207-F, Part VII. Record the joint density information and submit results on Department forms to the Engineer. The evaluation is considered failing if the joint density is more than 3.0 pcf below the density taken at the core random sample location and the correlated joint density is less than 90.0%. The Engineer will make independent joint density verification at least once per project and may make independent joint density verifications at the random sample locations. The Engineer's joint density test results will be used when available.

Provide the Engineer with the joint density of every sublot in the lot within one working day of the completion of each lot. Report the results of each joint density in accordance with Section 341.4.2., "Reporting and Responsibilities."

Investigate joint density failures and take corrective actions during production and placement to improve the joint density. Suspend production if the evaluations on 2 consecutive sublots fail unless otherwise approved. Resume production after the Engineer approves changes to production or placement methods.

4.9.3.3.4. **Recovered Asphalt Dynamic Shear Rheometer (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 Construction Division. The aging ratio is the DSR value of the extracted binder divided by the DSR value of the original unaged binder. Obtain DSR values in accordance with AASHTO T 315 at the specified high temperature performance grade of the asphalt. 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 in accordance with Tex-211-F.

4.9.3.3.5. **Irregularities**. Identify and correct irregularities including segregation, rutting, raveling, flushing, fat spots, mat slippage, irregular color, irregular texture, roller marks, tears, gouges, streaks, uncoated aggregate particles, or broken aggregate particles. The Engineer may also identify irregularities, and in such cases, the Engineer will promptly notify the Contractor. If the Engineer determines that the irregularity will adversely affect pavement performance, the Engineer may require the Contractor to remove and replace (at the Contractor's expense) areas of the pavement that contain irregularities and areas where the mixture does not bond to the existing pavement.

If irregularities are detected, the Engineer may require the Contractor to immediately suspend operations or may allow the Contractor to continue operations for no more than one day while the Contractor is taking appropriate corrective action.

4.9.4. **Exempt Production**. The Engineer may deem the mixture as exempt production for the following conditions:

- anticipated daily production is less than 1,000 tons;
- total production for the project is less than 5,000 tons;
- when mutually agreed between the Engineer and the Contractor; or
- when shown on the plans.

For exempt production, the Contractor is relieved of all production and placement sampling and testing requirements, and the production and placement pay factors are 1.000. All other specification requirements apply, and the Engineer will perform acceptance tests for production and placement listed in Table 14 when 100 tons or more per day are produced.

For exempt production:

- produce, haul, place, and compact the mixture in compliance with the specification and as directed;

- control mixture production to yield a laboratory-molded density that is within ±1.0% of the target laboratory-molded density as tested by the Engineer;
- compact the mixture in accordance with Section 341.4.8., "Compaction;" and
- when a thermal imaging system is not used, the Engineer may perform segregation (density profiles) and thermal profiles in accordance with the specification.

4.9.5. **Ride Quality**. Measure ride quality in accordance with Item 585, "Ride Quality for Pavement Surfaces," unless otherwise shown on the plans.

5. MEASUREMENT

Hot mix will be measured by the ton of composite hot-mix, which includes asphalt, aggregate, and additives. Measure the weight on scales in accordance with Item 520, "Weighing and Measuring Equipment."

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under Section 341.5., "Measurement," will be paid for at the unit bid price for "Dense Graded Hot-Mix Asphalt" of the mixture type, SAC, and binder specified. These prices are full compensation for surface preparation, materials including tack coat, placement, equipment, labor, tools, and incidentals.

Payment adjustments will be applied as determined in this Item; however, a payment adjustment factor of 1.000 will be assigned for all placement sublots for "level ups" only when "level up" is listed as part of the item bid description code. A payment adjustment factor of 1.000 will be assigned to all production and placement sublots when "exempt" is listed as part of the item bid description code.

Payment for each sublot, including applicable payment adjustments greater than 1.000, will only be paid for sublots when the Contractor supplies the Engineer with the required documentation for production and placement QC/QA, thermal profiles, segregation density profiles, and longitudinal joint densities in accordance with Section 341.4.2., "Reporting and Responsibilities." When a thermal imaging system is used, documentation is not required for thermal profiles or segregation density profiles on individual sublots; however, the thermal imaging system automated reports described in Tex-244-F are required.

Trial batches will not be paid for unless they are included in pavement work approved by the Department.

Payment adjustment for ride quality will be determined in accordance with Item 585, "Ride Quality for Pavement Surfaces."

6.1. **Production Payment Adjustment Factors**. The production payment adjustment factor is based on the laboratory-molded density using the Engineer's test results. A payment adjustment factor will be determined from Table 16 for each sublot using the deviation from the target laboratory-molded density defined in Table 9. The production payment adjustment factor for completed lots will be the average of the payment adjustment factors for the 4 sublots sampled within that lot.

Table 16
Production Payment Adjustment Factors for Laboratory-Molded Density[1]

Absolute Deviation from Target Laboratory-Molded Density	Production Payment Adjustment Factor (Target Laboratory-Molded Density)
0.0	1.050
0.1	1.050
0.2	1.050
0.3	1.044
0.4	1.038
0.5	1.031
0.6	1.025
0.7	1.019
0.8	1.013
0.9	1.006
1.0	1.000
1.1	0.965
1.2	0.930
1.3	0.895
1.4	0.860
1.5	0.825
1.6	0.790
1.7	0.755
1.8	0.720
> 1.8	Remove and replace

1. If the Engineer's laboratory-molded density on any sublot is less than 95.0% or greater than 98.0%, take immediate corrective action to bring the mixture within these tolerances. The Engineer may suspend operations if the Contractor's corrective actions do not produce acceptable results. The Engineer will allow production to resume when the proposed corrective action is likely to yield acceptable results.

6.1.1. **Payment for Incomplete Production Lots**. Production payment adjustments for incomplete lots, described under Section 341.4.9.2.1.1., "Incomplete Production Lots," will be calculated using the average production payment factors from all sublots sampled. A production payment factor of 1.000 will be assigned to any lot when the random sampling plan did not result in collection of any samples.

6.1.2. **Production Sublots Subject to Removal and Replacement**. If after referee testing, the laboratory-molded density for any sublot results in a "remove and replace" condition as listed in Table 16, the Engineer may require removal and replacement or may allow the sublot to be left in place without payment. The Engineer may also accept the sublot in accordance with Section 5.3.1., "Acceptance of Defective or Unauthorized Work." Replacement material meeting the requirements of this Item will be paid for in accordance with this Section.

6.2. **Placement Payment Adjustment Factors**. The placement payment adjustment factor is based on in-place air voids using the Engineer's test results. A payment adjustment factor will be determined from Table 17 for each sublot that requires in-place air void measurement. A placement payment adjustment factor of 1.000 will be assigned to the entire sublot when the random sample location falls in an area designated on the plans as not subject to in-place air void determination. A placement payment adjustment factor of 1.000 will be assigned to quantities placed in areas described in Section 341.4.9.3.1.4., "Miscellaneous Areas." The placement payment adjustment factor for completed lots will be the average of the placement payment adjustment factors for up to 4 sublots within that lot.

Table 17
Placement Payment Adjustment Factors for In-Place Air Voids

In-Place Air Voids	Placement Pay Adjustment Factor	In-Place Air Voids	Placement Pay Adjustment Factor
< 2.7	Remove and Replace	6.4	1.042
2.7	0.710	6.5	1.040
2.8	0.740	6.6	1.038
2.9	0.770	6.7	1.036
3.0	0.800	6.8	1.034
3.1	0.830	6.9	1.032
3.2	0.860	7.0	1.030
3.3	0.890	7.1	1.028
3.4	0.920	7.2	1.026
3.5	0.950	7.3	1.024
3.6	0.980	7.4	1.022
3.7	0.998	7.5	1.020
3.8	1.002	7.6	1.018
3.9	1.006	7.7	1.016
4.0	1.010	7.8	1.014
4.1	1.014	7.9	1.012
4.2	1.018	8.0	1.010
4.3	1.022	8.1	1.008
4.4	1.026	8.2	1.006
4.5	1.030	8.3	1.004
4.6	1.034	8.4	1.002
4.7	1.038	8.5	1.000
4.8	1.042	8.6	0.998
4.9	1.046	8.7	0.996
5.0	1.050	8.8	0.994
5.1	1.050	8.9	0.992
5.2	1.050	9.0	0.990
5.3	1.050	9.1	0.960
5.4	1.050	9.2	0.930
5.5	1.050	9.3	0.900
5.6	1.050	9.4	0.870
5.7	1.050	9.5	0.840
5.8	1.050	9.6	0.810
5.9	1.050	9.7	0.780
6.0	1.050	9.8	0.750
6.1	1.048	9.9	0.720
6.2	1.046	> 9.9	Remove and Replace
6.3	1.044		

6.2.1. **Payment for Incomplete Placement Lots**. Payment adjustments for incomplete placement lots described under Section 341.4.9.3.1.2., "Incomplete Placement Lots," will be calculated using the average of the placement payment factors from all sublots sampled and sublots where the random location falls in an area designated on the plans as not eligible for in-place air void determination. A placement payment adjustment factor of 1.000 will be assigned to any lot when the random sampling plan did not result in collection of any samples.

6.2.2. **Placement Sublots Subject to Removal and Replacement**. If after referee testing, the placement payment adjustment factor for any sublot results in a "remove and replace" condition as listed in Table 17, the Engineer will choose the location of 2 cores to be taken within 3 ft. of the original failing core location. The Contractor will obtain the cores in the presence of the Engineer. The Engineer will take immediate possession of the untrimmed cores and submit the untrimmed cores to the Construction Division, where they will be trimmed if necessary and tested for bulk specific gravity within 10 working days of receipt.

The average bulk specific gravity of the cores will be divided by the Engineer's average maximum theoretical specific gravity for that lot to determine the new payment adjustment factor of the sublot in question. If the new payment adjustment factor is 0.700 or greater, the new payment adjustment factor will apply to that sublot. If the new payment adjustment factor is less than 0.700, no payment will be made for the sublot.

Remove and replace the failing sublot, or the Engineer may allow the sublot to be left in place without payment. The Engineer may also accept the sublot in accordance with Section 5.3.1., "Acceptance of Defective or Unauthorized Work." Replacement material meeting the requirements of this Item will be paid for in accordance with this Section.

6.3. **Total Adjusted Pay Calculation**. Total adjusted pay (TAP) will be based on the applicable payment adjustment factors for production and placement for each lot.

TAP = (A+B)/2

where:
A = Bid price × production lot quantity × average payment adjustment factor for the production lot
B = Bid price × placement lot quantity × average payment adjustment factor for the placement lot + (bid price × quantity placed in miscellaneous areas × 1.000)

Production lot quantity = Quantity actually placed - quantity left in place without payment

Placement lot quantity = Quantity actually placed - quantity left in place without payment - quantity placed in miscellaneous areas

Item 354
Planing and Texturing Pavement

1. DESCRIPTION

Plane, or plane and texture, existing asphalt concrete pavement, asphalt-stabilized base, or concrete pavement. Texture bridge deck surfaces.

2. EQUIPMENT

The Engineer may require demonstration of the equipment's capabilities.

2.1. **Planing Machine**. Use planing machines that:

- have a minimum 6-ft. cutting width except for work areas less than 6 ft. wide;
- are self-propelled with enough power, traction, and stability to maintain an accurate depth of cut and slope;
- can cut in one continuous operation: 4 in. of asphalt concrete pavement, 1 in. of concrete pavement, or a combination of 2 in. of asphalt concrete pavement and 1/2 in. of concrete pavement;
- use dual longitudinal controls capable of operating on both sides automatically from any longitudinal grade reference, which includes string line, ski, mobile string line, or matching shoe;
- use transverse controls with an automatic system to control cross slope at a given rate;
- use integral loading and reclaiming devices to allow cutting, removal, and discharge of the material into a truck in one operation; and
- include devices to control dust created by the cutting action.

2.2. **Manual System**. Use a manual system that can achieve a uniform depth of cut, flush to all inlets, valve covers, manholes, and other appurtenances within the paved area. Use of a manual system is allowed for areas restricted to self-propelled access and for detail pavement removal.

2.3. **Sweeper**. Use a street sweeper to remove cuttings and debris from the planed or textured pavement unless otherwise approved. Equip the sweeper with a water tank, dust control spray assembly, both a pick-up and a gutter broom, and a debris hopper.

3. CONSTRUCTION

3.1. **Grade Reference**. Place grade reference points at maximum intervals of 50 ft. in accordance with Item 5, "Control of the Work," when required. Use the control points to set the grade reference. Support the grade reference so the maximum deflection does not exceed 1/16 in. between supports.

3.2. **Planing and Texturing**. Vary the speed of the machine to leave a grid or other pattern type with discontinuous longitudinal reach. Remove the pavement surface for the length, depth, and width shown on the typical section and to the established line and grades. Remove pavement to vertical lines adjacent to curbs, gutters, inlets, manholes, or other obstructions. Do not damage appurtenances or underlying pavement. Provide a planed surface that has a uniform textured appearance and riding surface. Surface should be free from gouges, continuous longitudinal grooves, ridges, oil film, and other imperfections of workmanship. Leave a uniform surface of concrete pavement free of asphalt materials when removing an asphalt concrete pavement overlay.

Provide a minimum texture depth of not less than 0.05 in. when an overlay on the planed pavement is not required. Stop planing operations when surface texture depth is not sufficient. Plane no more than 3/16 in.

into the original deck surface on bridges. Never damage armor joints, sealed expansion joints, and other appurtenances.

Provide a pavement surface that, after planing, has a smooth riding quality and is true to the established line, grade, and cross-section. Provide a pavement surface that does not vary more than 1/8 in. in 10 ft. Evaluate this criterion with a 10-ft. straightedge placed parallel to the centerline of the roadway. Deviations will be measured from the top of the texture. Correct any point in the surface not meeting this requirement.

Sweep pavement and gutter. Leave pavement and curb clean.

3.3. **Edge Treatments**. Slope vertical or near vertical longitudinal faces in the pavement surface for areas under traffic in accordance with the requirements on the plans at the end of the day. Taper transverse faces to provide an acceptable ride.

3.4. **Salvaged Materials**. The Department will retain ownership of planed materials unless otherwise shown on the plans. Stockpile salvaged materials at locations shown on the plans. Prepare the stockpile site by removing vegetation and trash and providing proper drainage. Keep salvaged paving material free from contamination during its removal, transportation, and storage. Place different types or quality of salvaged asphalt paving material into separate stockpiles. Dispose of unsalvageable material in accordance with applicable federal, state, and local regulations.

4. MEASUREMENT

This Item will be measured by the square yard of surface area for each pavement type including asphalt concrete pavement, concrete pavement, and bridge decks. Measurement will be based on the depth shown for each bid item, within the limits shown on the plans, regardless of the number of passes required. Only 1 bid item for each pavement type will apply to any 1 location.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Planing and Texturing Asphalt Concrete Pavement," "Planing and Texturing Concrete Pavement," "Planing Asphalt Concrete Pavement," or "Planing Concrete Pavement" of the depths specified, and for "Texturing Bridge Decks."

The planing of concrete pavement to remove all asphalt concrete pavement as required under Article 354.3., "Construction," is subsidiary to the planing of asphalt concrete pavement of the depth shown on the plans.

This price is full compensation for removing all material to the depth shown; texturing the pavement surface when texturing is shown in the bid item description; loading, hauling, and unloading; stockpiling or disposing of material; sweeping; tapering or sloping longitudinal or transverse joints as described under Section 354.3.3., "Edge Treatments"; and equipment, labor, tools, and incidentals. Demonstration work to receive approval for use of equipment will not be paid for unless work is performed in accordance with the Contract and is accepted.

Item 360
Concrete Pavement

1. DESCRIPTION

Construct hydraulic cement concrete pavement with or without curbs on the concrete pavement.

2. MATERIALS

2.1. **Hydraulic Cement Concrete**. Provide hydraulic cement concrete in accordance with Item 421, "Hydraulic Cement Concrete." Use compressive strength testing unless otherwise shown on the plans. Provide Class P concrete designed to meet a minimum average compressive strength of 3,200 psi or a minimum average flexural strength of 450 psi at 7 days or a minimum average compressive strength of 4,000 psi or a minimum average flexural strength of 570 psi at 28 days. Test in accordance with Tex-448-A or Tex-418-A.

Obtain written approval if the concrete mix design exceeds 520 lb. per cubic yard of cementitious material.

Use coarse aggregates for continuously reinforced concrete pavements to produce concrete with a coefficient of thermal expansion not more than 5.5×10^{-6} in./in./°F. Provide satisfactory Tex-428-A test data from an approved testing laboratory if the coarse aggregate coefficient of thermal expansion listed on the Department's *Concrete Rated Source Quality Catalog* is not equal to or less than 5.5×10^{-6} in./in./°F.

Provide Class HES concrete for very early opening of small pavement areas or leave-outs to traffic when shown on the plans or allowed. Design Class HES to meet the requirements of Class P and a minimum average compressive strength of 3,200 psi or a minimum average flexural strength of 450 psi in 24 hr., unless other early strength and time requirements are shown on the plans or allowed.

Use Class A or P concrete meeting the requirements of Item 421, "Hydrualic Cement Concrete," and this Item for curbs that are placed separately from the pavement.

2.2. **Reinforcing Steel**. Provide Grade 60 or above, deformed steel for bar reinforcement in accordance with Item 440, "Reinforcement for Concrete." Provide positioning and supporting devices (baskets and chairs) capable of securing and holding the reinforcing steel in proper position before and during paving. Provide corrosion protection when shown on the plans.

2.2.1. **Dowels**. Provide smooth, straight dowels of the size shown on the plans, free of burrs, and conforming to the requirements of Item 440, "Reinforcement for Concrete." Coat dowels with a thin film of grease, wax, silicone or other approved de-bonding material. Provide dowel caps on the lubricated end of each dowel bar used in an expansion joint. Provide dowel caps filled with a soft compressible material with enough range of movement to allow complete closure of the expansion joint.

2.2.2. **Tie Bars**. Provide straight deformed steel tie bars. Provide either multiple-piece tie bars or single-piece tie bars as shown on the plans. Furnish multiple piece tie bar assemblies from the list of approved multiple-piece tie bars that have been prequalified in accordance with DMS-4515, "Multiple Piece Tie Bars for Concrete Pavements," when used. Multiple-piece tie bars used on individual projects must be sampled in accordance with Tex-711-I, and tested in accordance with DMS-4515 "Multiple Piece Tie Bars for Concrete Pavements."

2.3. **Alternative Reinforcing Materials**. Provide reinforcement materials of the dimensions and with the physical properties specified when allowed or required by the plans. Provide manufacturer's certification of required material properties.

2.4. **Curing Materials**. Provide Type 2 membrane curing compound conforming to DMS-4650, "Hydraulic Cement Concrete Curing Materials and Evaporation Retardants." Provide SS-1 emulsified asphalt conforming to Item 300, "Asphalts, Oils, and Emulsions," for concrete pavement to be overlaid with asphalt concrete under this Contract unless otherwise shown on the plans or approved. Provide materials for other methods of curing conforming to the requirements of Item 422, "Concrete Superstructures." Provide insulating blankets for curing fast track concrete pavement with a minimum thermal resistance (R) rating of 0.5 hour-square foot F/BTU. Use insulating blankets that are free from tears and are in good condition.

2.5. **Epoxy**. Provide Type III, Class C epoxy in accordance with DMS-6100, "Epoxies and Adhesives," for installing all drilled-in reinforcing steel. Submit a work plan and request approval for the use of epoxy types other than Type III, Class C.

2.6. **Evaporation Retardant**. Provide evaporation retardant conforming to DMS-4650, "Hydraulic Cement Concrete Curing Materials and Evaporation Retardants."

2.7. **Joint Sealants and Fillers**. Provide Class 5 or Class 8 joint-sealant materials and fillers unless otherwise shown on the plans or approved and other sealant materials of the size, shape, and type shown on the plans in accordance with DMS-6310, "Joint Sealants and Fillers."

3. EQUIPMENT

Furnish and maintain all equipment in good working condition. Use measuring, mixing, and delivery equipment conforming to the requirements of Item 421, "Hydraulic Cement Concrete." Obtain approval for other equipment used.

3.1. **Placing, Consolidating, and Finishing Equipment**. Provide approved self-propelled paving equipment that uniformly distributes the concrete with minimal segregation and provides a smooth machine-finished consolidated concrete pavement conforming to plan line and grade. Provide an approved automatic grade control system on slip-forming equipment. Provide approved mechanically-operated finishing floats capable of producing a uniformly smooth pavement surface. Provide equipment capable of providing a fine, light water fog mist.

When string-less paving equipment is used, use Section 5.9.3, "Method C," and establish control points at maximum intervals of 500 ft. Use these control points as reference to perform the work.

Provide mechanically-operated vibratory equipment capable of adequately consolidating the concrete. Provide immersion vibrators on the paving equipment at sufficiently close intervals to provide uniform vibration and consolidation of the concrete over the entire width and depth of the pavement and in accordance with the manufacturer's recommendations. Provide immersion vibrator units that operate at a frequency in air of at least 8,000 cycles per minute. Provide enough hand-operated immersion vibrators for timely and proper consolidation of the concrete along forms, at all joints and in areas not covered by other vibratory equipment. Surface vibrators may be used to supplement equipment-mounted immersion vibrators. Provide tachometers to verify the proper operation of all vibrators.

For small or irregular areas or when approved, the paving equipment described in this Section is not required.

3.2. **Forming Equipment**.

3.2.1. **Pavement Forms**. Provide metal side forms of sufficient cross-section, strength, and rigidity to support the paving equipment and resist the impact and vibration of the operation without visible springing or settlement. Use forms that are free from detrimental kinks, bends, or warps that could affect ride quality or alignment. Provide flexible or curved metal or wood forms for curves of 100-ft. radius or less.

3.2.2. **Curb Forms**. Provide curb forms for separately placed curbs that are not slipformed that conform to the requirements of Item 529, "Concrete Curb, Gutter, and Combined Curb and Gutter."

3.3. **Reinforcing Steel Inserting Equipment**. Provide inserting equipment that accurately inserts and positions reinforcing steel in the plastic concrete parallel to the profile grade and horizontal alignment in accordance to plan details when approved.

3.4. **Texturing Equipment**.

3.4.1. **Carpet Drag**. Provide a carpet drag mounted on a work bridge or a manual moveable support system. Provide a single piece of carpet of sufficient transverse length to span the full width of the pavement being placed and adjustable so that a sufficient longitudinal length of carpet is in contact with the concrete being placed to produce the desired texture. Obtain approval to vary the length and width of the carpet to accommodate specific applications.

3.4.2. **Tining Equipment**. Provide a self-propelled metal tine device equipped with steel tines with cross-section approximately 1/32 in. thick × 1/12 in. wide. Provide tines for transverse tining equipment spaced at approximately 1 in., center-to-center, or provide tines for longitudinal tining equipment spaced at approximately 3/4 in., center-to-center. Manual methods that produce an equivalent texture may be used when it is impractical to use self-propelled equipment, such as for small areas, narrow width sections, and in emergencies due to equipment breakdown.

3.5. **Curing Equipment**. Provide a self-propelled machine for applying membrane curing compound using mechanically-pressurized spraying equipment with atomizing nozzles. Provide equipment and controls that maintain the required uniform rate of application over the entire paving area. Provide curing equipment that is independent of all other equipment when required to meet the requirements of Section 360.4.9., "Curing." Hand-operated pressurized spraying equipment with atomizing nozzles may only be used on small or irregular areas, narrow width sections, or in emergencies due to equipment breakdown.

3.6. **Sawing Equipment**. Provide power-driven concrete saws to saw the joints shown on the plans. Provide standby power-driven concrete saws during concrete sawing operations.

3.7. **Grinding Equipment**. Provide self-propelled powered grinding equipment that is specifically designed to smooth and texture concrete pavement using circular diamond blades when required. Provide equipment with automatic grade control capable of grinding at least a 3-ft. width longitudinally in each pass without damaging the concrete.

3.8. **Testing Equipment**. Provide testing equipment regardless of job-control testing responsibilities in accordance with Item 421, "Hydraulic Cement Concrete," unless otherwise shown on the plans or specified.

3.9. **Coring Equipment**. Provide coring equipment capable of extracting cores in accordance with the requirements of Tex-424-A when required.

3.10. **Miscellaneous Equipment**. Furnish both 10-ft. and 15-ft. steel or magnesium long-handled, standard straightedges. Furnish enough work bridges, long enough to span the pavement, for finishing and inspection operations.

4. CONSTRUCTION

Obtain approval for adjustments to plan grade-line to maintain thickness over minor subgrade or base high spots while maintaining clearances and drainage. Maintain subgrade or base in a smooth, clean, compacted condition in conformity with the required section and established grade until the pavement concrete is placed. Keep subgrade or base damp with water before placing pavement concrete.

Adequately light the active work areas for all nighttime operations. Provide and maintain tools and materials to perform testing.

4.1. **Paving and Quality Control Plan**. Submit a paving and quality control plan for approval before beginning pavement construction operations. Include details of all operations in the concrete paving process, including methods to construct transverse joints, methods to consolidate concrete at joints, longitudinal construction

joint layout, sequencing, curing, lighting, early opening, leave-outs, sawing, inspection, testing, construction methods, other details and description of all equipment. List certified personnel performing the testing. Submit revisions to the paving and quality control plan for approval.

4.2. **Job-Control Testing**. Perform all fresh and hardened concrete job-control testing at the specified frequency unless otherwise shown on the plans. Provide job-control testing personnel meeting the requirements of Item 421, "Hydraulic Cement Concrete." Provide and maintain testing equipment, including strength testing equipment at a location acceptable to the Engineer. Use of a commercial laboratory is acceptable. Maintain all testing equipment calibrated in accordance with pertinent test methods. Make strength-testing equipment available to the Engineer for verification testing.

Provide the Engineer the opportunity to witness all tests. The Engineer may require a retest if not given the opportunity to witness. Furnish a copy of all test results to the Engineer daily. Check the first few concrete loads for slump and temperature to verify concrete conformance and consistency on start-up production days. Sample and prepare strength-test specimens (2 specimens per test) on the first day of production and for each 3,000 sq. yd. or fraction thereof of concrete pavement thereafter. Prepare at least 1 set of strength-test specimens for each production day. Perform slump and temperature tests each time strength specimens are made. Monitor concrete temperature to ensure that concrete is consistently within the temperature requirements. The Engineer will direct random job-control sampling and testing. Immediately investigate and take corrective action as approved if any Contractor test result, including tests performed for verification purposes, does not meet specification requirements.

The Engineer will perform job-control testing when the testing by the Contractor is waived by the plans; however, this does not waive the Contractor's responsibility for providing materials and work in accordance with this Item.

4.2.1. **Job-Control Strength**. Use 7-day job-control concrete strength testing in accordance with Tex-448-A or Tex-418-A unless otherwise shown on the plans or permitted.

Use a compressive strength of 3,200 psi or a lower job-control strength value proven to meet a 28-day compressive strength of 4,000 psi as correlated in accordance with Tex-427-A for 7-day job-control by compressive strength. Use a flexural strength of 450 psi or a lower job-control strength value proven to meet a 28-day flexural strength of 570 psi as correlated in accordance with Tex-427-A for 7-day job-control by flexural strength.

Job control of concrete strength may be correlated to an age other than 7 days in accordance with Tex-427-A when approved. Job-control strength of Class HES concrete is based on the required strength and time.

Investigate the strength test procedures, the quality of materials, the concrete production operations, and other possible problem areas to determine the cause when a job-control concrete strength test value is more than 10% below the required job-control strength or when 3 consecutive job-control strength values fall below the required job-control strength. Take necessary action to correct the problem, including redesign of the concrete mix if needed. The Engineer may suspend concrete paving if the Contractor is unable to identify, document, and correct the cause of low-strength test values in a timely manner. The Engineer will evaluate the structural adequacy of the pavements if any job-control strength is more than 15% below the required job-control strength. Remove and replace pavements found to be structurally inadequate at no additional cost when directed.

4.2.2. **Split-Sample Verification Testing**. Perform split-sample verification testing with the Engineer on random samples taken and split by the Engineer at a rate of at least 1 for every 10 job-control samples. The Engineer will evaluate the results of split-sample verification testing. Immediately investigate and take corrective action as approved when results of split-sample verification testing differ more than the allowable differences shown in Table 1, or the average of 10 job-control strength results and the Engineer's split-sample strength result differ by more than 10%.

Table 1
Verification Testing Limits

Test Method	Allowable Differences
Temperature, Tex-422-A	2°F
Flexural strength, Tex-448-A	19%
Compressive strength, Tex-418-A	10%

4.3. **Reinforcing Steel and Joint Assemblies**. Accurately place and secure in position all reinforcing steel as shown on the plans. Place dowels at mid-depth of the pavement slab, parallel to the surface. Place dowels for transverse contraction joints parallel to the pavement edge. Tolerances for location and alignment of dowels will be shown on the plans. Stagger the lap locations so that no more than 1/3 of the longitudinal steel is spliced in any given 12-ft. width and 2-ft. length of the pavement. Use multiple-piece tie bars, drill and epoxy grout tie bars, or, if approved, mechanically-inserted single-piece tie bars at longitudinal construction joints. Verify that tie bars that are drilled and epoxied or mechanically inserted into concrete at longitudinal construction joints develop a pullout resistance equal to a minimum of 3/4 of the yield strength of the steel after 7 days. Test 15 bars using ASTM E488, except that alternate approved equipment may be used. All 15 tested bars must meet the required pullout strength. Perform corrective measures to provide equivalent pullout resistance if any of the test results do not meet the required minimum pullout strength. Repair damage from testing. Acceptable corrective measures include but are not limited to installation of additional or longer tie bars.

4.3.1. **Manual Placement**. Secure reinforcing bars at alternate intersections with wire ties or locking support chairs. Tie all splices with wire.

4.3.2. **Mechanical Placement**. Complete the work using manual placement methods described above if mechanical placement of reinforcement results in steel misalignment or improper location, poor concrete consolidation, or other inadequacies.

4.4. **Joints**. Install joints as shown on the plans. Joint sealants are not required on concrete pavement that is to be overlaid with asphaltic materials. Clean and seal joints in accordance with Item 438, “Cleaning and Sealing Joints.” Repair excessive spalling of the joint saw groove using an approved method before installing the sealant. Seal all joints before opening the pavement to all traffic. Install a rigid transverse bulkhead, for the reinforcing steel, and shaped accurately to the cross-section of the pavement when placing of concrete is stopped.

4.4.1. **Placing Reinforcement at Joints**. Complete and place the assembly of parts at pavement joints at the required location and elevation, with all parts rigidly secured in the required position, when shown on the plans.

4.4.2. **Transverse Construction Joints**.

4.4.2.1. **Continuously Reinforced Concrete Pavement (CRCP)**. Install additional longitudinal reinforcement through the bulkhead when shown on the plans. Protect the reinforcing steel immediately beyond the construction joint from damage, vibration, and impact.

4.4.2.2. **Concrete Pavement Contraction Design (CPCD)**. Install and rigidly secure a complete joint assembly and bulkhead in the planned transverse contraction joint location when the placing of concrete is intentionally stopped. Install a transverse construction joint either at a planned transverse contraction joint location or mid-slab between planned transverse contraction joints when the placing of concrete is unintentionally stopped. Install tie bars of the size and spacing used in the longitudinal joints for mid-slab construction joints.

4.4.2.3. **Curb Joints**. Provide joints in the curb of the same type and location as the adjacent pavement. Use expansion joint material of the same thickness, type, and quality required for the pavement and of the section shown for the curb. Extend expansion joints through the curb. Construct curb joints at all transverse pavement joints. Place reinforcing steel into the plastic concrete pavement for non-monolithic curbs as shown on the plans unless otherwise approved. Form or saw the weakened plane joint across the full width of concrete pavement and through the monolithic curbs. Construct curb joints in accordance with Item 529, “Concrete Curb, Gutter, and Combined Curb and Gutter.”

4.5. **Placing and Removing Forms**. Use clean and oiled forms. Secure forms on a base or firm subgrade that is accurately graded and that provides stable support without deflection and movement by form riding equipment. Pin every form at least at the middle and near each end. Tightly join and key form sections together to prevent relative displacement.

Set side forms far enough in advance of concrete placement to permit inspection. Check conformity of the grade, alignment, and stability of forms immediately before placing concrete, and make all necessary corrections. Use a straightedge or other approved method to test the top of forms to ensure that the ride quality requirements for the completed pavement will be met. Stop paving operations if forms settle or deflect more than 1/8 in. under finishing operations. Reset forms to line and grade, and refinish the concrete surface to correct grade.

Avoid damage to the edge of the pavement when removing forms. Repair damage resulting from form removal and honeycombed areas with a mortar mix within 24 hr. after form removal unless otherwise approved. Clean joint face and repair honeycombed or damaged areas within 24 hr. after a bulkhead for a transverse construction joint has been removed unless otherwise approved. Promptly apply membrane curing compound to the edge of the concrete pavement when forms are removed before 72 hr. after concrete placement.

Forms that are not the same depth as the pavement, but are within 2 in. of that depth are permitted if the subbase is trenched or the full width and length of the form base is supported with a firm material to produce the required pavement thickness. Promptly repair the form trench after use. Use flexible or curved wood or metal forms for curves of 100-ft. radius or less.

4.6. **Concrete Delivery**. Clean delivery equipment as necessary to prevent accumulation of old concrete before loading fresh concrete. Use agitated delivery equipment for concrete designed to have a slump of more than 5 in. Segregated concrete is subject to rejection.

Begin the discharge of concrete delivered in agitated delivery equipment conforming to the requirements of Item 421, “Hydraulic Cement Concrete.” Place non-agitated concrete within 45 min. after batching. Reduce times as directed when hot weather or other conditions cause quick setting of the concrete.

4.7. **Concrete Placement**. Do not allow the pavement edge to deviate from the established paving line by more than 1/2 in. at any point. Place the concrete as near as possible to its final location, and minimize segregation and rehandling. Distribute concrete using shovels where hand spreading is necessary. Do not use rakes or vibrators to distribute concrete.

4.7.1. **Consolidation**. Consolidate all concrete by approved mechanical vibrators operated on the front of the paving equipment. Use immersion-type vibrators that simultaneously consolidate the full width of the placement when machine finishing. Keep vibrators from dislodging reinforcement. Use hand-operated vibrators to consolidate concrete along forms, at all joints and in areas not accessible to the machine-mounted vibrators. Do not operate machine-mounted vibrators while the paving equipment is stationary. Vibrator operations are subject to review.

4.7.2. **Curbs**. Conform to the requirements of Item 529, “Concrete Curb, Gutter, and Combined Curb and Gutter” where curbs are placed separately.

4.7.3. **Temperature Restrictions**. Place concrete that is between 40°F and 95°F when measured in accordance with Tex-422-A at the time of discharge, except that concrete may be used if it was already in transit when the temperature was found to exceed the allowable maximum. Take immediate corrective action or cease concrete production when the concrete temperature exceeds 95°F.

Do not place concrete when the ambient temperature in the shade is below 40°F and falling unless approved. Concrete may be placed when the ambient temperature in the shade is above 35°F and rising or above 40°F. Protect the pavement with an approved insulating material capable of protecting the concrete for the specified curing period when temperatures warrant protection against freezing. Submit for approval

proposed measures to protect the concrete from anticipated freezing weather for the first 72 hr. after placement. Repair or replace all concrete damaged by freezing.

4.8. **Spreading and Finishing**. Finish all concrete pavement with approved self-propelled equipment. Use power-driven spreaders, power-driven vibrators, power-driven strike-off, screed, or approved alternate equipment. Use the transverse finishing equipment to compact and strike-off the concrete to the required section and grade without surface voids. Use float equipment for final finishing. Use concrete with a consistency that allows completion of all finishing operations without addition of water to the surface. Use the minimal amount of water fog mist necessary to maintain a moist surface. Reduce fogging if float or straightedge operations result in excess slurry.

4.8.1. **Finished Surface**. Perform sufficient checks with long-handled 10-ft. and 15-ft. straightedges on the plastic concrete to ensure the final surface is within the tolerances specified in Surface Test A in Item 585, "Ride Quality for Pavement Surfaces." Check with the straightedge parallel to the centerline.

4.8.2. **Maintenance of Surface Moisture**. Prevent surface drying of the pavement before application of the curing system by means that may include water fogging, the use of wind screens, and the use of evaporation retardants. Apply evaporation retardant at the manufacturer's recommended rate. Reapply the evaporation retardant as needed to maintain the concrete surface in a moist condition until curing system is applied. Do not use evaporation retardant as a finishing aid. Failure to take acceptable precautions to prevent surface drying of the pavement will be cause for shutdown of pavement operations.

4.8.3. **Surface Texturing**. Complete final texturing before the concrete has attained its initial set. Drag the carpet longitudinally along the pavement surface with the carpet contact surface area adjusted to provide a satisfactory coarsely textured surface. Prevent the carpet from getting plugged with grout. Do not perform carpet dragging operations while there is excessive bleed water.

A metal-tine texture finish is required unless otherwise shown on the plans. Provide transverse tining unless otherwise shown on the plans. Immediately following the carpet drag, apply a single coat of evaporation retardant, if needed, at the rate recommended by the manufacturer. Provide the metal-tine finish immediately after the concrete surface has set enough for consistent tining. Operate the metal-tine device to obtain grooves approximately 3/16 in. deep, with a minimum depth of 1/8 in., and approximately 1/12 in. wide. Do not overlap a previously tined area. Use manual methods to achieve similar results on ramps, small or irregular areas, and narrow width sections of pavements. Repair damage to the edge of the slab and joints immediately after texturing. Do not tine pavement that will be overlaid or that is scheduled for blanket diamond grinding or shot blasting.

Target a carpet drag texture of 0.04 in., as measured by Tex-436-A, when carpet drag is the only surface texture required on the plans. Ensure adequate and consistent macro-texture is achieved by applying enough weight to the carpet and by keeping the carpet from getting plugged with grout. Correct any location with a texture less than 0.03 in. by diamond grinding or shot blasting. The Engineer will determine the test locations at points located transversely to the direction of traffic in the outside wheel path.

4.8.4. **Small, Irregular Area, or Narrow Width Placements**. Use hand equipment and procedures that produce a consolidated and finished pavement section to the line and grade where machine placements and finishing of concrete pavement are not practical.

4.8.5. **Emergency Procedures**. Use hand-operated equipment for applying texture, evaporation retardant, and cure in the event of equipment breakdown.

4.9. **Curing**. Keep the concrete pavement surface from drying as described in Section 360.4.8.2., "Maintenance of Surface Moisture," until the curing material has been applied. Maintain and promptly repair damage to curing materials on exposed surfaces of concrete pavement continuously for at least 3 curing days. A curing day is defined as a 24-hr. period when either the temperature taken in the shade away from artificial heat is above 50°F for at least 19 hr. or the surface temperature of the concrete is maintained above 40°F for 24 hr. Curing begins when the concrete curing system has been applied. Stop concrete paving if curing compound

is not being applied promptly and maintained adequately. Other methods of curing in accordance with Item 422, "Concrete Superstructures," may be used when specified or approved.

4.9.1. **Membrane Curing**. Spray the concrete surface uniformly with 2 coats of membrane curing compound at an individual application rate of no more than 180 sq. ft. per gallon. Apply the curing compound before allowing the concrete surface to dry.

Manage finishing and texturing operations to ensure placement of curing compound on a moist concrete surface, relatively free of bleed water, to prevent any plastic shrinkage cracking. Time the application of curing compound to prevent plastic shrinkage cracking.

Maintain curing compounds in a uniformly agitated condition, free of settlement before and during application. Do not thin or dilute the curing compound.

Apply additional compound at the same rate of coverage to correct damage where the coating shows discontinuities or other defects or if rain falls on the newly coated surface before the film has dried enough to resist damage. Ensure that the curing compound coats the sides of the tining grooves.

4.9.2. **Asphalt Curing**. Apply a uniform coating of asphalt curing at a rate of 90 to 180 sq. ft. per gallon when an asphaltic concrete overlay is required. Apply curing immediately after texturing and once the free moisture (sheen) has disappeared. Obtain approval to add water to the emulsion to improve spray distribution. Maintain the asphalt application rate when using diluted emulsions. Maintain the emulsion in a mixed condition during application.

4.9.3. **Curing Class HES Concrete**. Provide membrane curing in accordance with Section 360.4.9.1., "Membrane Curing," for all Class HES concrete pavement. Promptly follow by wet mat curing in accordance with Section 422.4.8., "Final Curing," until opening strength is achieved but not less than 24 hr.

4.9.4. **Curing Fast-Track Concrete Pavement**. Provide wet mat curing unless otherwise shown on the plans or as directed. Cure in accordance with Section 422.4.8., "Final Curing." Apply a Type 1-D or Type 2 membrane cure instead of wet mat curing if the air temperature is below 65°F and insulating blankets are used.

4.10. **Sawing Joints**. Saw joints to the depth shown on the plans as soon as sawing can be accomplished without damage to the pavement regardless of time of day or weather conditions. Some minor raveling of the saw-cut is acceptable. Use a chalk line, string line, sawing template, or other approved method to provide a true joint alignment. Provide enough saws to match the paving production rate to ensure sawing completion at the earliest possible time to avoid uncontrolled cracking. Reduce paving production if necessary to ensure timely sawing of joints. Promptly restore membrane cure damaged within the first 72 hr. of curing.

4.11. **Protection of Pavement and Opening to Traffic**. Testing for early opening is the responsibility of the Contractor regardless of job-control testing responsibilities unless otherwise shown on the plans or as directed. Testing result interpretation for opening to traffic is subject to approval.

4.11.1. **Protection of Pavement**. Erect and maintain barricades and other standard and approved devices that will exclude all vehicles and equipment from the newly placed pavement for the periods specified. Protect the pavement from damage due to crossings using approved methods before opening to traffic. Where a detour is not readily available or economically feasible, an occasional crossing of the roadway with overweight equipment may be permitted for relocating equipment only but not for hauling material. When an occasional crossing of overweight equipment is permitted, temporary matting or other approved methods may be required.

Maintain an adequate supply of sheeting or other material to cover and protect fresh concrete surface from weather damage. Apply as needed to protect the pavement surface from weather.

4.11.2. **Opening Pavement to All Traffic**. Pavement that is 7 days old may be opened to all traffic. Clean pavement, place stable material against the pavement edges, seal joints, and perform all other traffic safety related work before opening to traffic.

4.11.3. **Opening Pavement to Construction Equipment**. Unless otherwise shown on the plans, concrete pavement may be opened early to concrete paving equipment and related delivery equipment after the concrete is at least 48 hr. old and opening strength has been demonstrated in accordance with Section 360.4.11.4., "Early Opening to All Traffic," before curing is complete. Keep delivery equipment at least 2 ft. from the edge of the concrete pavement. Keep tracks of the paving equipment at least 1 ft. from the pavement edge. Protect textured surfaces from the paving equipment. Restore damaged membrane curing as soon as possible. Repair pavement damaged by paving or delivery equipment before opening to all traffic.

4.11.4. **Early Opening to All Traffic**. Concrete pavement may be opened after curing is complete and the concrete has attained a flexural strength of 450 psi or a compressive strength of 3,200 psi, except that pavement using Class HES concrete may be opened after 24 hr. if the specified strength is achieved.

4.11.4.1. **Strength Testing**. Test concrete specimens cured under the same conditions as the portion of the pavement involved.

4.11.4.2. **Maturity Method**. Use the maturity method, Tex-426-A, to estimate concrete strength for early opening pavement to traffic unless otherwise shown on the plans. Install at least 2 maturity sensors for each day's placement in areas where the maturity method will be used for early opening. Maturity sensors, when used, will be installed near the day's final placement for areas being evaluated for early opening. Use test specimens to verify the strength–maturity relationship in accordance with Tex-426-A, starting with the first day's placement corresponding to the early opening pavement section.

Verify the strength–maturity relationship at least every 10 days of production after the first day. Establish a new strength–maturity relationship when the strength specimens deviate more than 10% from the maturity-estimated strengths. Suspend use of the maturity method for opening pavements to traffic when the strength–maturity relationship deviates by more than 10% until a new strength–maturity relationship is established.

The Engineer will determine the frequency of verification when the maturity method is used intermittently or for only specific areas.

4.11.5. **Fast Track Concrete Pavement**. Open the pavement after the concrete has been cured for at least 8 hr. and attained a minimum compressive strength of 1,800 psi or a minimum flexural strength of 255 psi when tested in accordance with Section 360.4.11.4.1., "Strength Testing," or Section 360.4.11.4.2., "Maturity Method," unless otherwise directed. Cover the pavement with insulating blankets when the air temperature is below 65°F until the pavement is opened to traffic.

4.11.6. **Emergency Opening to Traffic**. Open the pavement to traffic under emergency conditions, when the pavement is at least 72 hr. old when directed in writing. Remove all obstructing materials, place stable material against the pavement edges, and perform other work involved in providing for the safety of traffic as required for emergency opening.

4.12. **Pavement Thickness**. The Engineer will check the thickness in accordance with Tex-423-A unless other methods are shown on the plans. The Engineer will perform 1 thickness test consisting of 1 reading at approximately the center of the paving equipment every 500 ft. or fraction thereof. Core where directed, in accordance with Tex-424-A, to verify deficiencies of more than 0.2 in. from plan thickness and to determine the limits of deficiencies of more than 0.75 in. from plan thickness. Fill core holes using an approved concrete mixture and method.

4.12.1. **Thickness Deficiencies Greater than 0.2 in.** Take one 4-in. diameter core at that location to verify the measurement when any depth test measured in accordance with Tex-423-A is deficient by more than 0.2 in. from the plan thickness.

Take 2 additional cores from the unit (as defined in Section 360.4.12.3., "Pavement Units for Payment Adjustment" at intervals of at least 150 ft. and at selected locations if the core is deficient by more than 0.2 in., but not by more than 0.75 in. from the plan thickness, and determine the thickness of the unit for payment purposes by averaging the length of the 3 cores. In calculations of the average thickness of this unit

of pavement, measurements in excess of the specified thickness by more than 0.2 in. will be considered as the specified thickness plus 0.2 in.

4.12.2. **Thickness Deficiencies Greater than 0.75 in.** Take additional cores at 10-ft. intervals in each direction parallel to the centerline to determine the boundary of the deficient area if a core is deficient by more than 0.75 in. The Engineer will evaluate any area of pavement found deficient in thickness by more than 0.75 in., but not more than 1 in. Remove and replace the deficient areas without additional compensation or retain deficient areas without compensation, as directed. Remove and replace any area of pavement found deficient in thickness by more than 1 in. without additional compensation.

4.12.3. **Pavement Units for Payment Adjustment**. Limits for applying a payment adjustment for deficient pavement thickness from 0.20 in. to not more than 0.75 in. are 500 ft. of pavement in each lane. Lane width will be as shown on typical sections and pavement design standards.

For greater than 0.75 in. deficient thickness, the limits for applying zero payment or requiring removal will be defined by coring or equivalent nondestructive means as determined by the Engineer. The remaining portion of the unit determined to be less than 0.75 in. deficient will be subject to the payment adjustment based on the average core thickness at each end of the 10-ft. interval investigation as determined by the Engineer.

Shoulders will be measured for thickness unless otherwise shown on the plans. Shoulders 6 ft. wide or wider will be considered as lanes. Shoulders less than 6 ft. wide will be considered part of the adjacent lane.

Limits for applying payment adjustment for deficient pavement thickness for ramps, widenings, acceleration and deceleration lanes, and other miscellaneous areas are 500 ft. in length. Areas less than 500 ft. in length will be individually evaluated for payment adjustment based on the plan area.

4.13. **Ride Quality**. Measure ride quality in accordance with Item 585, “Ride Quality for Pavement Surfaces,” unless otherwise shown on the plans.

5. MEASUREMENT

This Item will be measured as follows:

5.1. **Concrete Pavement**. Concrete pavement will be measured by the square yard of surface area in place. The surface area includes the portion of the pavement slab extending beneath the curb.

5.2. **Curb**. Curb on concrete pavement will be measured by the foot in place.

6. PAYMENT

These prices are full compensation for materials, equipment, labor, tools, and incidentals.

6.1. **Concrete Pavement**. The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the adjusted unit price bid for “Concrete Pavement” of the type and depth specified as adjusted in accordance with Section 360.6.2., “Deficient Thickness Adjustment.”

6.2. **Deficient Thickness Adjustment**. Where the average thickness of pavement is deficient in thickness by more than 0.2 in. but not more than 0.75 in., payment will be made using the adjustment factor as specified in Table 2 applied to the bid price for the deficient area for each unit as defined under Section 360.4.12.3., “Pavement Units for Payment Adjustment.”

Table 2
Deficient Thickness Price Adjustment Factor

Deficiency in Thickness Determined by Cores (in.)	Proportional Part of Contract Price Allowed (Adjustment Factor)
Not deficient	1.00
Over 0.00 through 0.20	1.00
Over 0.20 through 0.30	0.80
Over 0.30 through 0.40	0.72
Over 0.40 through 0.50	0.68
Over 0.50 through 0.75	0.57

6.3. **Curb**. Work performed and furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Curb" of the type specified.

Item 361
Repair of Concrete Pavement

1. DESCRIPTION

Repair concrete pavement to half-depth or full-depth in accordance with the details shown on the plans and the requirements of this Item.

2. MATERIALS

Furnish materials in accordance with the following:

- Item 360, "Concrete Pavement,"
- Item 421, "Hydraulic Cement Concrete,"
- Item 440, "Reinforcement for Concrete,"
- DMS-6100, "Epoxies and Adhesives," and
- DMS-4655, "Concrete Repair Materials."

2.1. **Half-Depth Repair**. Obtain approval for the repair material mix design. The selection of repair material should be based on the time for opening to traffic and temperature range during the repair.

Provide Class HES concrete in accordance with Item 421, "Hydrualic Cement Concrete," and designed to attain a minimum average flexural strength of 255 psi or a minimum average compressive strength of 1,800 psi within the timeframe designated for opening to traffic if it is less than 72 hr. after concrete placement. Otherwise, provide Class S conforming to Item 421, "Hydraulic Cement Concrete" or Class P concrete conforming to Item 360, "Concrete Pavement."

Provide material meeting the requirements of DMS-4655, "Concrete Repair Materials," Type A when Class HES concrete does not meet the strength requirement within the designated timeframe.

2.2. **Full-Depth Repair**. Obtain approval for the repair material mix design. The selection of repair material should be based on the time for opening to traffic and temperature range during the repair.

2.2.1. **Hydraulic Cement Concrete for Pavement**. Provide Class HES concrete designed to attain a minimum average flexural strength of 255 psi or a minimum average compressive strength of 1,800 psi within the designated timeframe if the timeframe designated for opening to traffic is less than 72 hr. after concrete placement. Otherwise, provide Class P concrete conforming to Item 360, "Concrete Pavement."

2.2.2. **Base Material**. Furnish cold-mix asphaltic materials for replacement base material when shown on the plans. The Engineer may waive quality control (QC) tests for base material.

2.2.3. **Asphalt Concrete**. Furnish asphalt concrete material for overlay and asphalt shoulder repair as shown on the plans. The Engineer may waive QC tests for this material.

3. EQUIPMENT

Provide tools and equipment necessary for proper execution of the work that meet the pertinent requirements of the following:

- Item 360, "Concrete Pavement"
- **Concrete Demolition Equipment**. Provide chipping hammers or hydro-demolition equipment for the bulk removal of concrete.

- **Concrete Lift-Out Equipment**. Provide steel chains, lift pins, and a crane or front-end loader capable of lifting the concrete and loading it onto a flatbed or dump truck.
- **Drill**. Use a maximum 40-lb. drill with tungsten carbide bits.
- **Air Compressor**. Provide compressor equipped with filters designed to remove oil from the air and capable of delivering air to remove dust and debris.

4. CONSTRUCTION

Submit for approval all materials and methods of application at least 2 weeks before beginning any repair work. Repair locations will be as indicated on the plans or as directed. Repair areas may be adjusted after removing distressed concrete. Switch the half-depth repair to the full-repair if exposed existing longitudinal bars are deficient, as approved. Compensation will be made for unexpected volumes of repair areas or changes in scope of work.

4.1. **Half-Depth Repair**. Repair locations will be as indicated on the plans or as directed. Repair boundaries should be square or rectangular with a minimum length and width of 12 in.

Saw-cut repair boundaries to a minimum depth of 1-1/2 in. Do not saw-cut longitudinal or transverse steel. If the longitudinal steel is cut, a full-depth repair may be required as directed without additional compensation.

Remove concrete from the repair area as designated. Start at the center of the repair area. Ensure all loose concrete materials are removed and only sound concrete is left in place. Increase the repair area and perform a full-depth repair as directed if longitudinal steel bars were damaged by the removal operations. No additional compensation will be made.

Clean the area to be repaired by approved methods. Remove all loose particles, dirt, deteriorated concrete, or other substances that would impair the bond of the repair material.

Mix, place, and cure in accordance with the manufacturer's recommendation when material in DMS-4655, "Concrete Repair Materials," is used. Mix, place, and cure concrete in accordance with Item 360, "Concrete Pavement." when Class S, Class P, or Class HES is used. Test Class S, Class P, and Class HES concrete to the requirements of Section 360.4.2., "Job-Control Testing."

Match the grade and alignment of existing concrete pavement unless otherwise shown on the plans. Concrete pavement may be opened to traffic when specified strength is achieved.

4.2. **Full-Depth Repair**. Repair areas identified by the Engineer. Make repair areas rectangular, at least 6 ft. long and at least 1/2 a full lane in width unless otherwise shown on the plans. Accept ownership of all removed material, and dispose of it in accordance with federal, state, and local regulations unless otherwise shown on the plans. Saw-cut and remove existing asphalt concrete overlay at least 2 ft. longer than the repair patch in each longitudinal direction when there is existing asphalt concrete overlay over the repair area.

Saw-cut the full depth through the concrete around the perimeter of the repair area before removal. Schedule work so that concrete placement follows full-depth saw-cutting by no more than 7 days unless otherwise shown on the plans or approved.

Remove the slab by lifting the slab with a minimum disturbance to the base materials and surrounding concrete. Do not spall or fracture concrete adjacent to the repair area. Saw-cut and remove additional concrete as directed, after slab removal, if distresses are found in the surrounding concrete pavement. Repair damages to concrete pavement caused by the Contractor's operation without additional compensation. Perform repairs as directed.

Remove loose or damaged base material completely, leaving no loose base material.

Recompact base materials to the satisfaction of the Engineer. Level the base layer with cold-mix asphalt to the original bottom line and grade of the concrete slab before repair concrete is placed when shown on the plans. Place concrete directly onto the compacted base layer unless otherwise directed.

Use tie bars to restore the continuity of the concrete pavement. Demonstrate, through simulated job conditions, that the bond strength of the epoxy-grouted tie bars meets a pullout strength of at least 3/4 of the yield strength of the tie bar when tested in accordance with ASTM E488 within the epoxy manufacturer's recommended curing time. Increase embedment depth and retest when necessary to meet testing requirements. Perform tie bar testing before starting repair work.

Place tie bars as shown on the plans. Drill holes into the existing concrete at least 10 in. deep unless otherwise directed. Use a drill bit with a diameter that is 1/8 in. greater than that of tie bars. Clean the holes with a wire brush and compressed air to remove all the dust and moisture. Follow the epoxy manufacturer's instructions to apply the epoxy. Insert the tip of the epoxy cartridge or the tip of the machine applicator to the end of the tie bar hole, and inject Type III, Class C epoxy to fill the entire hole. Insert tie bars.

Place new deformed reinforcing steel bars of the same size and spacing as shown on the plans for Continuously Reinforced Concrete Pavement (CRCP) repairs. Lap all longitudinal reinforcing steel at least 25 in. Provide and place approved supports to firmly hold the new reinforcing steel in place when needed.

Place dowel bars as shown on the plans for Concrete Pavement Contraction Design (CPCD) repairs. Provide and place approved supports to firmly hold the dowel bars in place.

Mix, place, cure, and test concrete to the requirements of Item 360, "Concrete Pavement," and Item 421, "Hydraulic Cement Concrete." Broom-finish the concrete surface unless otherwise shown on the plans.

Perform a timely saw-cut over the dowel bars and restore the transverse contraction joint for CPCD. Restore the existing longitudinal joints to the requirements of Section 360.4.4., "Joints."

Match the grade and alignment of existing concrete pavement. Replace any asphalt overlay and shoulder material removed with new asphalt concrete material after concrete strength requirements have been met.

Remove repair area debris from the right of way each day. Concrete pavement may be opened to traffic when specified strength is achieved.

5. MEASUREMENT

This Item will be measured by the square yard in place of the completed concrete surface area repaired.

6. PAYMENT

The work performed and the materials furnished in accordance with this Item and measured as specified under "Measurement" will be paid for at the unit price bids for "Repair of Concrete Pavement (Half-Depth)" and "Repair of Concrete Pavement (Full-Depth)." This price is full compensation for removal, stockpiling, and disposal of waste material and for equipment, materials, labor, tools, and incidentals. Asphalt concrete, base material, and curbing will not be paid for directly but will be considered subsidiary to this Item.

Item 427
Surface Finishes for Concrete

1. DESCRIPTION

Finish concrete surface as specified.

2. MATERIALS

Furnish materials in accordance with this Article for the type of surface finish specified.

2.1. **Coatings**.

2.1.1. **Adhesive Grout and Concrete Paint**. Provide coatings in accordance with DMS-8110, "Coatings for Concrete." Match color of coating with Federal Standard 595C color 35630, concrete gray, unless otherwise shown on the plans.

2.1.2. **Opaque Sealer**. Provide penetrating-type sealer in accordance with DMS-8110, "Coatings for Concrete." Match color of coating with Federal Standard 595C color 35630, concrete gray, unless otherwise shown on the plans.

2.1.3. **Silicone-Based Paint**. Provide silicone resin emulsion paint (SREP) meeting the requirements of DMS-8141, "Paint, Silicon Resin for Concrete." Match color of coating with Federal Standard 595C color 35630, concrete gray, unless otherwise shown on the plans.

2.2. **Exposed Aggregate Finish**. Provide approved aggregates meeting the grading requirements shown on the plans. Provide gravel consisting of predominantly rounded particles unless otherwise shown on the plans. Use crushed stone when a bush-hammered finish is desired. Provide a concrete surface retardant. Provide clear Type II permanent anti-graffiti coating in accordance with DMS-8111, "Anti-Graffiti Coatings."

3. EQUIPMENT

The Engineer may require demonstration of the equipment's capabilities.

3.1. **Low-Pressure Water Blasting**. Use equipment capable of supplying a minimum pressure at the nozzle end of 3,000 psi at a minimum flow rate of 3 gpm. Use a 0° rotary, vibratory, or wobble-type nozzle. Use equipment capable of including abrasives in the water stream when specified on the plans.

3.2. **Abrasive Blasting**. Use equipment with filters to produce oil-free air and also water-free air when dry air is required.

3.3. **Slurry Blasting**. Use equipment capable of combining air and abrasives with water to form a wet blast media capable of cleaning and preparing surface without creating dust.

3.4. **Spraying**. Use equipment with fluid and air pressure regulators and gauges to allow for adjustment to produce a uniform spray pattern for spray applications.

3.5. **Off-the-Form Finish Forms**. Use nonstaining, nonporous, high-quality forming materials (e.g., steel or medium-density and high-density overlaid plywood forms). Use steel or high-density overlaid plywood forms when the same form will be used more than twice.

3.6. **Form Liners**. Provide form liners capable of producing a patterned finish as shown on the plans. Use form liners that provide a clean release from the concrete surface without pulling or breaking the textured concrete.

4. CONSTRUCTION

Provide the finish specified on the plans for the specific surface areas.

4.1. **Surface Areas of Finish**. "Surface area of finish" designates the areas where the specified surface is to be applied.

4.1.1. **Surface Area I**.

- surfaces of railing;
- exterior vertical faces of fascia beams, slabs, slab spans, arches, and box girders;
- the outside bottom surface of fascia beams and girders;
- the underside of overhanging slabs to the point of juncture of the supporting beam;
- the entire underside of slab spans when shown on the plans;
- vertical and underside surfaces of bents and piers;
- all surfaces of tie beams, abutments, bridge wingwalls, culvert headwalls and wingwalls, and retaining walls exposed to view after all backfill and embankment is placed; and
- all other exposed surfaces shown on the plans to require surface treatment.

4.1.2. **Surface Area II**. Surfaces of railing, all wingwalls, and the exterior vertical faces of slabs.

4.1.3. **Surface Area III**. Only the top and roadway faces of all concrete railing and bridge wingwalls.

4.1.4. **Surface Area IV**. Areas designated on the plans.

4.2. **Coatings**. Apply the coating specified on the plans.

4.2.1. **Preparation**. Clean the surface thoroughly before applying a coating by chemical cleaning, if required, and by blast cleaning.

Submit a containment plan that details the procedures proposed to keep public property, private property, and the environment from being adversely affected by the cleaning and painting operations. Do not discharge washwater into body of water or conveyance without TCEQ approval. Collect and properly dispose of any paint or debris dislodged as a result of cleaning operations.

4.2.1.1. **Chemical Cleaning**. Clean surfaces contaminated with oil, grease, or other contaminants by scrubbing the area with an approved detergent or other concrete cleaning material before blast cleaning. Do not use a solvent that will stain the surface or inhibit coating adhesion. Perform the following test to check for surface contamination of oil type materials:

- Spray the surface with a fine mist of potable water.
- Examine the area to see if water beads up.
- Clean the surface if beading is found.

4.2.1.2. **Blast Cleaning**. Blast clean the designated surface to remove weak surface material, curing compound, and other contaminants before applying a specified coating, leaving a lightly etched uniformly textured surface. Use an approved abrasive propelled by oil-free air with or without the addition of potable water, or blast with potable water with or without the addition of an approved abrasive at sufficient pressure to effectively clean and prepare the surface. Maintain the stand-off-distance of the nozzle to a maximum of 12 in. from the surface being cleaned when water blasting.

Do not damage concrete surface by gouging, spalling, or exposing coarse aggregate by the blasting operation.

Blow clean oil- and moisture-free air on all surfaces with sufficient pressure to remove loose particles immediately before application of any coating. Perform the following test to check for surface cleanliness as directed:

- Press a 10 in. long strip of 2 in. wide clear packing tape on the surface by rubbing with moderate pressure.
- Grasp the free end of the tape, and remove the tape from the surface with a sharp jerk.
- Examine the surface of the tape for clinging particles.

Continue cleaning the concrete surface until there are no particles clinging to the tape surface for subsequent tests. An additional test that can be used to check the surface for dust is to wipe the surface with a dark cloth and then examine the cloth for discoloration.

4.2.2. **Application**. Mix coating materials thoroughly with a mechanical mixer at a speed that causes the mixture to rotate entirely in the container. Ensure complete mixing by probing the container with a stirring device searching for non-dispersed or settled material.

Apply coatings once the new concrete has aged a minimum of 28 days except for the adhesive grout coating. Do not apply coatings when weather conditions will be detrimental to the final surface finish as determined by the Engineer. Do not apply coatings when surface temperature of the concrete exceeds 110°F.

Apply coatings to obtain a consistent color and texture.

4.2.2.1. **Adhesive Grout**. Apply coating on a moistened surface to a uniform minimum thickness of 1/16 in. Apply when ambient temperature is at least 50°F.

4.2.2.2. **Concrete Paint**. Apply the coating on a dry surface in 2 coats for a total maximum application rate of 150 sq. ft. per gallon. Match the color of the applied coating with the color standard shown on the plans. Do not thin material unless approved. Apply when ambient temperature is between 50°F and 100°F.

4.2.2.3. **Opaque Sealer**. Apply the coating to a dry surface in 2 coats for a total maximum application rate of 200 sq. ft. per gallon. Match the color of the applied coating with the approved color standard shown on the plans. Do not thin the material unless approved. Apply when ambient temperature is between 40°F and 100°F.

4.2.2.4. **Silicone Resin Paint**. Apply the coating on a dry surface in 2 coats at a rate not exceeding 300 sq. ft. per gallon per coat. Do not thin the material unless approved. Wait a minimum of 12 hr. between coats. Apply when ambient temperature is between 50°F and 100°F.

Repair surface finish where coating has been applied that exhibits peeling, flaking, or discoloration or has been damaged during construction. Remove defective or damaged coating. Clean and recoat repair area in accordance with the requirements of this Item.

4.3. **Special Surface Finishes**. Submit a work plan to the Engineer for any special finish shown on the plans. Include in the work plan the type of aggregates, materials, variation of panel or pattern arrangement, dimensions, construction methods, and other features affecting the work as is necessary for the “Special Surface Finish” specified.

4.3.1. **Blast Finish**. Provide surface profile as shown on the plans, or meet the minimum requirements of Section 427.4.2.1., “Preparation.” Construct a 4 × 4 ft. sample panel using the same concrete used in construction of the member to receive the blast finish. Prepare the surface of the sample panel to meet the specified finish, and obtain approval of the sample finish. Use the approved sample panel finish as the standard for surfaces requiring a blast finish.

4.3.2. **Slurry Coat Finish**. Provide cementitious slurry coat finish to concrete surfaces within 14 days of placing concrete or later as approved. Water blast surface to moisten surface before application when application of slurry coat occurs more than 14 days after placing concrete. Do not apply slurry coat finish to surfaces receiving another type coating finish.

Submit for approval proposed slurry recipe including cement, latex concrete additive, with or without sand, and other additives before application. The Engineer will direct the level of surface texture the slurry coat will have, whether to include sand, and what fineness of sand is to be used. Tint mixture of slurry as specified on the plans and as directed. Maintain consistent slurry throughout project only modifying recipe to account for color variations being noticed as work progresses.

Rub in slurry with carborundum stone, stiff bristle brush, or other approved device. Limit thickness of applied slurry to a maximum of 1/16 in. thick. Demonstrate application methods for slurry coat and obtain approval of proposed surface. Apply slurry coat to obtain a tightly adhering cementitious finish to concrete surface. Remove material and reapply if slurry coat is not tightly adhering or is cracked.

4.3.3. **Rub Finish**. Provide a finish to the surface by rubbing the surface with a carborundum stone or other approved material. Begin rubbing the surface immediately after forms have been removed. Provide blast finish or other finish as directed at no additional cost to the Department if rubbing surface is delayed to the point where the surface is dry and unable to be rubbed to produce an acceptable finish. Perform the requirements to obtain the ordinary surface finish specified in Section 420.4.13., “Ordinary Surface Finish,” concurrently with rubbing the surface. Rub concrete-patching areas after the patch material has thoroughly set and blend the patch in with the surrounding area to produce a surface with uniform color and texture where concrete patching is performed.

Keep the surface continuously wet after form removal until the rubbing is complete. Rub the surface sufficiently to bring the wetted concrete surface to a paste producing a smooth dense surface without pits, form marks, or other irregularities. Do not use cement grout to form the paste on the surface. Stripe the surface with a brush to conceal the rubbing pattern and allow the paste to reset. Wash the concrete with potable water after the paste has sufficiently set to leave it with a neat and uniform appearance and texture. Apply membrane curing, if required, in accordance with Item 420, “Concrete Substructures,” after rubbing is complete.

4.3.4. **Off-the-Form Finish**. Provide a finish with minimal surface defects and uniform color and texture by using non-staining, non-porous, high-quality forming materials. Use the same type of forming materials for like elements for the entire structure.

Use mortar-tight forms to prevent leakage and discoloration. Seal joints with compressible gasket material, caulk, tape, or by other suitable means that are not detrimental to the concrete finish if necessary. Use one brand and type of form-release agents for all surfaces unless another product produces a similar concrete surface appearance. Do not use barrier-type (wax, fuel oil, carrier oil, etc.) release agents. Use form-release agents containing a rust inhibitor on steel forms. Clean rust off steel forms before use. Use plywood that will not cause discoloration of the concrete surface.

Direct special attention to consolidation and vibration of the concrete around the form surfaces to minimize bug holes. Modify concrete placement and vibration techniques if surface contains an excessive amount of bug holes. Remove all forms without interruption once form removal begins to prevent discoloration due to differing form curing times.

Do not use membrane curing on surfaces with off-the-form finish.

Repair honeycombed and spall areas with least dimension larger than 2 in. in accordance with the concrete surface repair procedures outlined in Item 420, “Concrete Substructures,” to obtain an ordinary surface finish as defined in Section 420.4.13., “Ordinary Surface Finish.” Patch honeycombed and spall areas with least dimension greater than 3/4 in. but smaller than 2 in. by filling defect with repair material omitting the chipping operation. Do not patch honeycombed and spall areas with least dimension smaller than 3/4 in. Perform required repairs as soon as forms are removed. Match repair material color and texture with surrounding

concrete surfaces. Minimize the area of repair by not smearing the repair material over acceptable concrete surfaces in an attempt to blend the repair with the surrounding concrete. Cut out form ties at least 1/2 in. below the surface, and patch accordingly. Perform repair work as soon as possible after removing forms so that concrete and repair material have similar ages. Replace or refurbish the forms when the Engineer determines defective formwork is causing an excessive amount of repair work.

4.3.5. **Form Liner Finish**. Provide patterned finish as shown on the plans. Do not splice form liner panels in a way that causes a noticeable transition or line between pieces. Wash and clean form liners after each use when the forms can be reused. Replace form liners that have become damaged or worn.

Construct a sample panel for each form liner finish. Approval is required to verify the sample panel meets the requirements of the plans and specifications before beginning work. Upon approval, the sample panel becomes the model panel that all other work will be compared against. Deviation in color, grade, or depth from the model panel is grounds for rejection of the form liner finish. Removal of defective work may be necessary as determined by the Engineer and in accordance with the surface finish requirements outlined in Item 420, "Concrete Substructures," to obtain an ordinary surface finish as defined in Section 420.4.13., "Ordinary Surface Finish."

Seal all form liner joints in a manner acceptable to the Engineer to prevent leakage at the surface.

4.3.6. **Exposed Aggregate Finish**. Provide exposed aggregate finish as indicated on the plans. Provide a depth of finish between 3/8 in. and 1/2 in. unless directed otherwise.

Apply a concrete surface retarder that penetrates approximately 1/4 in. into the forms or concrete surface to help achieve the desired finish. Apply 2 or 3 coats to wood forms to account for absorption if necessary. Tape or caulk form joints to prevent escape of the retarder during the placing operations. Protect the form surfaces from sun and rain while exposed to the atmosphere. Re-treat form surfaces with retarder if disturbed. Protect adjacent areas of concrete not requiring exposed aggregate finish from the retarder.

Remove forms 12 to 15 hr. after concrete placement but not before concrete has gained sufficient strength to support the self-weight of the member unless directed otherwise. Expose the aggregate for the finish immediately after form removal. Remove the grout paste covering the aggregate to be exposed by an approved method. Do not loosen the aggregate by the grout removal operation. Maintain required curing on all surfaces except for the time while the aggregate is being exposed. Cure using wet mats or membrane after the aggregate is exposed.

Repair defective areas as determined by the Engineer.

Re-clean exposed aggregate surfaces by an approved method. Apply a coat of clear Type II permanent anti-graffiti coating to cleaned exposed aggregate surface. Apply anti-graffiti coatings by spray, roller, or brush at the application rates recommended by the manufacturer and in accordance with Item 740, "Graffiti Removal and Anti-Graffiti Coating."

5. MEASUREMENT

When surface finishes for concrete is shown on the plans to be a pay item, measurement will be by the square foot of the type of surface finish specified.

This is a plans quantity measurement Item. The quantity to be paid is the quantity shown in the proposal, unless modified by Article 9.2., "Plans Quantity Measurement." Additional measurement or calculations will be made if adjustments of quantities are required.

6. PAYMENT

Unless otherwise specified on the plans, the work performed, materials furnished, equipment, labor, tools, and incidentals will not be paid for directly but will be considered subsidiary to pertinent Items.

When a surface finish for concrete is specified as a pay item, the work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for “Adhesive Grout Finish,” “Concrete Paint Finish,” “Opaque Sealer Finish,” “Silicone Resin Paint Finish,” or “Blast Finish.” This price is full compensation for materials; cleaning and preparing surfaces; application of materials; and equipment, labor, tools, and incidentals.

Slurry coat, rub, off-the-form, form liner, or exposed aggregate finishes (including anti-graffiti coating) will not be paid for under this Item but are subsidiary to other pertinent Items.

Item 440
Reinforcement for Concrete

1. DESCRIPTION

Furnish and place reinforcement of the type, size, and details shown on the plans.

2. MATERIALS

Use deformed steel bar reinforcement unless otherwise specified or allowed.

2.1. **Approved Mills**. Before furnishing steel, producing mills of reinforcing steel for the Department must be pre-approved in accordance with DMS-7320, "Qualification Procedure for Reinforcing Steel Producing Mills," by the Construction Division. The Department's MPL has a list of approved producing mills. Reinforcing steel obtained from unapproved sources will not be accepted.

Contact the Construction Division with the name and location of the producing mill for stainless reinforcing steel, low carbon/chromium reinforcing steel, or dual-coated reinforcing steel at least 4 weeks before ordering any material.

2.2. **Deformed Steel Bar Reinforcement**. Provide deformed reinforcing steel conforming to one of the following:

- ASTM A615, Grades 60, 75, or 80;
- ASTM A996, Type A, Grade 60;
- ASTM A996, Type R, Grade 60, permitted in concrete pavement only (Furnish ASTM A996, Type R bars as straight bars only and do not bend them. Bend tests are not required.); or
- ASTM A706, Grades 60 or 80.

Provide the grade of reinforcing steel shown on the plans. Provide Grade 60 if no grade is shown.

The nominal size, area, and weight of reinforcing steel bars this Item covers are shown in Table 1.

Table 1
Size, Area, and Weight of Reinforcing Steel Bars

Bar Size Number (in.)	Diameter (in.)	Area (sq. in.)	Weight per Foot (lbs.)
3	0.375	0.11	0.376
4	0.500	0.20	0.668
5	0.625	0.31	1.043
6	0.750	0.44	1.502
7	0.875	0.60	2.044
8	1.000	0.79	2.670
9	1.128	1.00	3.400
10	1.270	1.27	4.303
11	1.410	1.56	5.313
14	1.693	2.25	7.650
18	2.257	4.00	13.60

2.3. **Smooth Steel Bar Reinforcement**. Provide smooth bars for concrete pavement with a yield strength of at least 60 ksi and meeting ASTM A615. Provide steel conforming to ASTM A615 or meet the physical requirements of ASTM A36 for smooth bars that are larger than No. 3. Designate smooth bars by size number up to No. 4 and by diameter in inches above No. 4.

2.4. **Spiral Reinforcement**. Provide bars or wire for spiral reinforcement of the grade and minimum size or gauge shown on the plans.

Provide smooth or deformed wire conforming to ASTM A1064. Provide bars conforming to ASTM A615; ASTM A996, Type A; or ASTM A675, Grade 80, meeting dimensional requirements of ASTM A615.

2.5. **Weldable Reinforcing Steel**. Provide reinforcing steel conforming to ASTM A706 or with a maximum carbon equivalent (C.E.) of 0.55% if welding of reinforcing steel is required or desired. Provide a report showing the percentages of elements necessary to establish C.E. for reinforcing steel that does not meet ASTM A706, in order to be structurally welded. These requirements do not pertain to miscellaneous welds on reinforcing steel as defined in Section 448.4.2.1.1., "Miscellaneous Welding Applications."

Calculate C.E. using the following formula:

$$C.E. = \%C + \frac{\%Mn}{6} + \frac{\%Cu}{40} + \frac{\%Ni}{20} + \frac{\%Cr}{10} - \frac{\%Mo}{50} - \frac{\%V}{10}$$

Do not weld stainless reinforcing steel without permission from the Engineer. Provide stainless reinforcing steel suitable for welding, if required, and submit welding procedures and electrodes to the Engineer for approval.

2.6. **Welded Wire Reinforcement**. Provide welded wire reinforcement (WWR) conforming to ASTM A1064. Observe the relations shown in Table 2 among size number, diameter in inches, and area when ordering wire by size numbers, unless otherwise specified. Precede the size number for deformed wire with "D" and for smooth wire with "W."

Designate WWR as shown in the following example: 6 × 12 – W16 × W8 (indicating 6-in. longitudinal wire spacing and 12-in. transverse wire spacing with smooth No. 16 wire longitudinally and smooth No. 8 wire transversely).

Table 2
Wire Size Number, Diameter, and Area

Size Number (in.)	Diameter (in.)	Area (sq. in.)
31	0.628	0.310
30	0.618	0.300
28	0.597	0.280
26	0.575	0.260
24	0.553	0.240
22	0.529	0.220
20	0.505	0.200
18	0.479	0.180
16	0.451	0.160
14	0.422	0.140
12	0.391	0.120
10	0.357	0.100
8	0.319	0.080
7	0.299	0.070
6	0.276	0.060
5.5	0.265	0.055
5	0.252	0.050
4.5	0.239	0.045
4	0.226	0.040
3.5	0.211	0.035
2.9	0.192	0.035
2.5	0.178	0.025
2	0.160	0.020
1.4	0.134	0.014
1.2	0.124	0.012
0.5	0.080	0.005

Note—Size numbers (in.) are the nominal cross-sectional area of the wire in hundredths of a square inch. Fractional sizes between the sizes listed above are also available and acceptable for use.

2.7. **Epoxy Coating**. Provide epoxy coated reinforcing steel as shown on the plans. Before furnishing epoxy coated reinforcing steel, an epoxy applicator must be pre-approved in accordance with DMS-7330, "Qualification Procedure for Reinforcing Steel Epoxy Coating Applicators." The Department's MPL has a list of approved applicators.

Furnish coated reinforcing steel meeting the requirements in Table 3.

Table 3
Epoxy Coating Requirements for Reinforcing Steel

Material	Specification
Bar	ASTM A775 or A934
Wire or WWR	ASTM A884 Class A or B
Mechanical couplers	As shown on the plans
Hardware	As shown on the plans

Use epoxy coating material and coating repair material that complies with DMS-8130, "Epoxy Powder Coating for Reinforcing Steel." Patch no more than 1/4-in. total length in any foot at the applicator's plant.

Maintain identification of all reinforcing steel throughout the coating and fabrication process and until delivery to the project site.

Furnish 1 copy of a written certification verifying the coated reinforcing steel meets the requirements of this Item and 1 copy of the manufacturer's control tests.

2.8. **Mechanical Couplers**. Use couplers of the type specified in DMS-4510, "Mechanical Couplers for Reinforcing Steel," Article 4510.5.A, "General Requirements," when mechanical splices in reinforcing steel bars are shown on the plans.

Furnish only couplers pre-qualified in accordance with DMS-4510, "Mechanical Couplers for Reinforcing Steel." Ensure sleeve-wedge type couplers are not used on coated reinforcing. Sample and test couplers for use on individual projects in accordance with DMS-4510, "Mechanical Couplers for Reinforcing Steel." Furnish couplers only at locations shown on the plans.

Furnish couplers for stainless reinforcing steel with the same alloy designation as the reinforcing steel.

2.9. **Fibers**. Supply fibers conforming to DMS-4550 "Fibers for Concrete" at the minimum dosage listed in the Department's MPL, when allowed by the plans. Use non-metallic fibers when shown on the plans.

2.10. **Stainless Reinforcing Steel**. Provide deformed steel bars of the types listed in Table 4 and conforming to ASTM A955, Grade 60 or higher when stainless reinforcing steel is required on the plans.

Table 4
Acceptable Types of Deformed Stainless Steel Bar

UNS Designation	S31653	S31803	S24100	S32304
AISI Type	316LN	2205	XM-28	2304

2.11. **Low Carbon/Chromium Reinforcing Steel**. Provide deformed steel bars conforming to ASTM A1035, Grade 100 when low carbon/chromium reinforcing steel is required on the plans.

2.12. **Dual-Coated Reinforcing Steel**. Provide deformed bars conforming to ASTM A1055, Grade 60 or higher when dual-coated reinforcing steel is required on the plans.

2.13. **Glass Fiber Reinforced Polymer Bars (GFRP)**. Provide bars conforming to the AASHTO LRFD *Bridge Design Guide Specifications for GFRP-Reinforced Concrete Bridge Decks and Traffic Railings*, Section 4, "Material Specifications" when GFRP bars are required on the plans. Provide sample certification demonstrating the GFRP bar supplier has produced bar that meets the Material Specifications 2 mo. before fabrication. Furnish certification upon shipment that the GFRP bar supplied meets the Material Specifications.

3. CONSTRUCTION

3.1. **Bending**. Fabricate reinforcing steel bars as prescribed in the CRSI *Manual of Standard Practice* to the shapes and dimensions shown on the plans. Fabricate in the shop if possible. Field-fabricate, if permitted, using a method approved by the Engineer. Replace improperly fabricated, damaged, or broken bars at no additional expense to the Department. Repair damaged or broken bars embedded in a previous concrete placement using a method approved by the Engineer.

Unless otherwise shown on the plans, the inside diameter of bar bends, in terms of the nominal bar diameter (d), must be as shown in Table 5.

Table 5
Minimum Inside Diameter of Bar Bends

Bend	Bar Size Number (in.)	Pin Diameter
Bends of 90° and greater in stirrups, ties, and other secondary bars that enclose another bar in the bend	3, 4, 5	4d
	6, 7, 8	6d
Bends in main bars and in secondary bars not covered above	3 through 8	6d
	9, 10, 11	8d
	14, 18	10d

Bend-test representative specimens as described for smaller bars in the applicable ASTM specification where bending No. 14 or No. 18 Grade 60 bars is required. Make the required 90° bend around a pin with a diameter of 10 times the nominal diameter of the bar.

Bend stainless reinforcing steel in accordance with ASTM A955.

3.2. **Tolerances**. Fabrication tolerances for bars are shown in Figure 1.

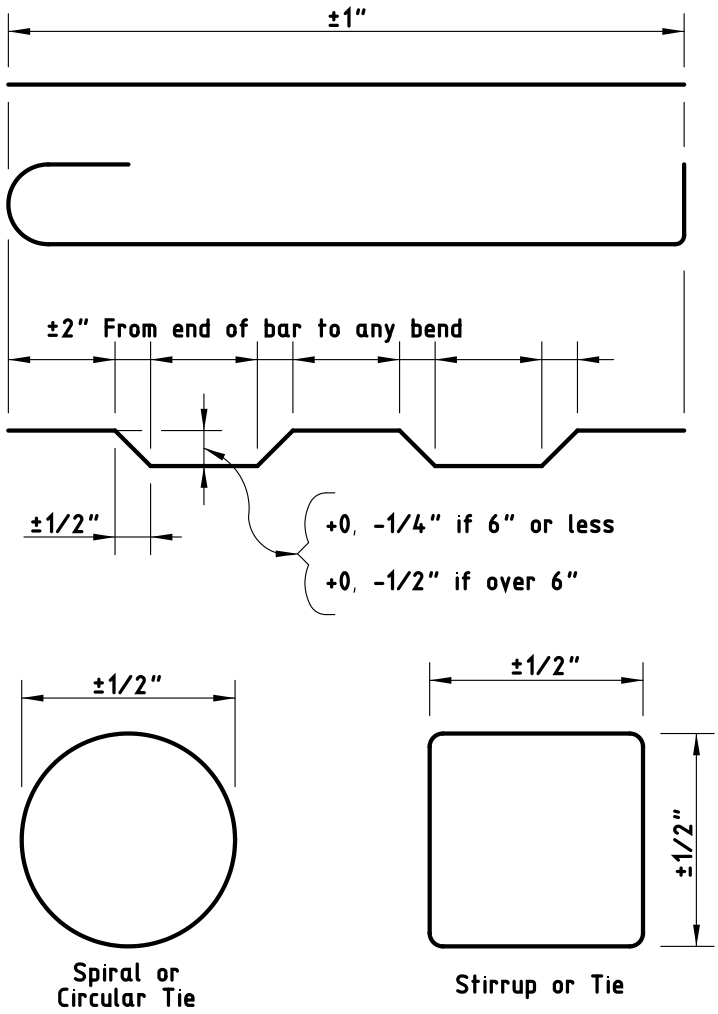

Figure 1
Fabrication Tolerances for Bars

3.3. **Storage**. Store reinforcement above the ground on platforms, skids, or other supports, and protect it from damage and deterioration. Ensure reinforcement is free from dirt, paint, grease, oil, and other foreign materials when it is placed in the work. Use reinforcement free from defects such as cracks and delaminations. Rust, surface seams, surface irregularities, or mill scale will not be cause for rejection if the minimum cross-sectional area of a hand wire-brushed specimen meets the requirements for the size of steel specified.

Do not allow stainless reinforcing steel to be in direct contact with uncoated reinforcing steel, nor with galvanized reinforcing steel. This does not apply to stainless steel wires and ties. Store stainless reinforcing steel separately, off the ground on wooden supports.

3.4. **Splices**. Lap-splice, weld-splice, or mechanically splice bars as shown on the plans. Additional splices not shown on the plans will require approval. Splices not shown on the plans will be permitted in slabs no more than 15 in. in thickness, columns, walls, and parapets.

- Do not splice bars less than 30 ft. in plan length unless otherwise approved. For bars exceeding 30 ft. in plan length, the distance center-to-center of splices must be at least 30 ft. minus 1 splice length, with no more than 1 individual bar length less than 10 ft. Make lap splices not shown on the plans, but otherwise

permitted, in accordance with Table 6. Maintain the specified concrete cover and spacing at splices, and place the lap-spliced bars in contact, securely tied together.

Table 6
Minimum Lap Requirements for Steel Bar Sizes through No. 11

Bar Size Number (in.)	Uncoated Lap Length	Coated Lap Length
3	1 ft. 4 in.	2 ft. 0 in.
4	1 ft. 9 in.	2 ft. 8 in.
5	2 ft. 2 in.	3 ft. 3 in.
6	2 ft. 7 in.	3 ft. 11 in.
7	3 ft. 5 in.	5 ft. 2 in.
8	4 ft. 6 in.	6 ft. 9 in.
9	5 ft. 8 in.	8 ft. 6 in.
10	7 ft. 3 in.	10 ft. 11 in.
11	8 ft. 11 in.	13 ft. 5 in.

- Do not lap No. 14 or No. 18 bars.
- Lap spiral steel at least 1 turn.
- Splice WWR using a lap length that includes the overlap of at least 2 cross wires plus 2 in. on each sheet or roll. Splices using bars that develop equivalent strength and are lapped in accordance with Table 6 are permitted.
- Lap the existing longitudinal bars with the new bars as shown in Table 6 for box culvert extensions with less than 1 ft. of fill. Lap at least 1 ft. 0 in. for extensions with more than 1 ft. of fill.
- Ensure welded splices conform to the requirements of the plans and of Item 448, "Structural Field Welding." Field-prepare ends of reinforcing bars if they will be butt-welded. Delivered bars must be long enough to permit weld preparation.
- Install mechanical coupling devices in accordance with the manufacturer's recommendations at locations shown on the plans. Protect threaded male or female connections, and ensure the threaded connections are clean when making the connection. Do not repair damaged threads.
- Mechanical coupler alternate equivalent strength arrangements, to be accomplished by substituting larger bar sizes or more bars, will be considered if approved in writing before fabrication of the systems.

3.5. **Placing**. Place reinforcement as near as possible to the position shown on the plans. Do not vary bars from plan placement by more than 1/12 of the spacing between bars in the plane of the bar parallel to the nearest surface of concrete. Do not vary bars from plan placement by more than 1/4 in in the plane of the bar perpendicular to the nearest surface of concrete. Provide a minimum 1-in. clear cover of concrete to the nearest surface of bar unless otherwise shown on the plans.

For bridge slabs, the clear cover tolerance for the top mat of reinforcement is −0, +1/2 in.

Locate the reinforcement accurately in the forms, and hold it firmly in place before and during concrete placement by means of bar supports that are adequate in strength and number to prevent displacement and keep the reinforcement at the proper distance from the forms. Provide bar supports in accordance with the CRSI *Manual of Standard Practice*. Use Class 1 supports, approved plastic bar supports, precast mortar, or concrete blocks when supports are in contact with removable or stay-in-place forms. Use Class 3 supports in slab overlays on concrete panels or on existing concrete slabs. Bar supports in contact with soil or subgrade must be approved.

Use Class 1A supports with epoxy coated reinforcing steel. Provide epoxy or plastic coated tie wires and clips for use with epoxy coated reinforcing steel.

Use mortar or concrete with a minimum compressive strength of 5,000 psi for precast bar supports. Provide a suitable tie wire in each block for anchoring to the bar.

Place individual bar supports in rows at 4-ft. maximum spacing in each direction. Place continuous type bar supports at 4-ft. maximum spacing. Use continuous bar supports with permanent metal deck forms.

The exposure of the ends of longitudinals, stirrups, and spacers used to position the reinforcement in concrete pipe and storm drains is not cause for rejection.

Tie reinforcement for bridge slabs and top slabs of direct traffic culverts at all intersections, except tie only alternate intersections where spacing is less than 1 ft. in each direction. Tie the bars at enough intersections to provide a rigid cage of reinforcement for reinforcement cages for other structural members. Fasten mats of WWR securely at the ends and edges.

Clean mortar, mud, dirt, debris, oil, and other foreign material from the reinforcement before concrete placement. Do not place concrete until authorized.

Stop placement until corrective measures are taken if reinforcement is not adequately supported or tied to resist settlement, reinforcement is floating upward, truss bars are overturning, or movement is detected in any direction during concrete placement.

3.6. **Handling, Placing, and Repairing Epoxy Coated Reinforcing Steel**.

3.6.1. **Handling**. Provide systems for handling coated reinforcing steel with padded contact areas. Pad bundling bands or use suitable banding to prevent damage to the coating. Lift bundles of coated reinforcement with a strongback, spreader bar, multiple supports, or a platform bridge. Transport the bundled reinforcement carefully, and store it on protective cribbing. Do not drop or drag the coated reinforcement.

3.6.2. **Placing**. Do not flame-cut coated reinforcement. Saw or shear-cut only when approved. Coat cut ends as specified in Section 440.3.6.3., “Repairing Coating.”

Do not weld or mechanically couple coated reinforcing steel except where specifically shown on the plans. Remove the epoxy coating at least 6 in. beyond the weld limits before welding and 2 in. beyond the limits of the coupler before assembly. Clean the steel of oil, grease, moisture, dirt, welding contamination (slag or acid residue), and rust to a near-white finish after welding or coupling. Check the existing epoxy for damage. Remove any damaged or loose epoxy back to sound epoxy coating.

Coat the splice area after cleaning with epoxy repair material to a thickness of 7 to 17 mils after curing. Apply a second application of repair material to the bar and coupler interface to ensure complete sealing of the joint.

3.6.3. **Repairing Coating**. Use material that complies with the requirements of this Item and ASTM D3963 for repairing of the coating. Make repairs in accordance with procedures recommended by the manufacturer of the epoxy coating powder. Apply at least the same coating thickness as required for the original coating for areas to be patched. Repair all visible damage to the coating.

Repair sawed and sheared ends, cuts, breaks, and other damage promptly before additional oxidation occurs. Clean areas to be repaired to ensure they are free from surface contaminants. Make repairs in the shop or field as required.

3.7. **Handling and Placing Stainless Reinforcing Steel**. Handle, cut, and place stainless reinforcing steel bar using tools that are not used on carbon steel. Do not use carbon steel tools, chains, slings, etc. when handling stainless steel. Use only nylon or polypropylene slings. Cut stainless steel reinforcing using shears, saws, abrasive cutoff wheels, or torches. Remove any thermal oxidation using pickling paste. Do not field bend stainless steel reinforcing without approval.

Use 16 gauge fully annealed stainless steel tie wire conforming to the material properties listed in Section 440.2.10., “Stainless Reinforcing Steel.” Support all stainless reinforcing steel on solid plastic, stainless steel, or epoxy coated steel chairs. Do not use uncoated carbon steel chairs in contact with stainless reinforcing steel.

3.8. **Bending, Handling, Repairing, and Placing GFRP Bars**. Fabricate, handle, repair, and place GFRP bars in accordance with the AASHTO LRFD Bridge Design Guide Specifications for GFRP-Reinforced Concrete Bridge Decks and Traffic Railings, Section 5, Construction Specifications.

4. MEASUREMENT AND PAYMENT

The work performed, materials furnished, equipment, labor, tools, and incidentals will not be measured or paid for directly but will be considered subsidiary to pertinent Items.

Item 460
Corrugated Metal Pipe

1. DESCRIPTION

Furnish and install corrugated metal pipes, materials for constructing corrugated metal pipe culverts, or corrugated metal storm drain mains, laterals, stubs, and inlet leads.

2. MATERIALS

2.1. **Fabrication**. Furnish corrugated metal pipe in accordance with Table 1.

Table 1
Specifications for Corrugated Metal Pipe

Pipe Type	AASHTO Specification
Galvanized steel and aluminized steel	M 36
Aluminized Type 2	M 36
Polymer Coated	M 36 & M 245
Asphalt Coated	M 36
Aluminum	M 196

The pipe type and corresponding AASHTO designations are shown in Table 2.

Table 2
Corrugated Metal Pipe Types

Pipe Type	AASHTO Classification
Circular	Type I
Circular, smooth-lined	Type IA
Circular, spiral rib	Type IR
Arch	Type II
Arch, smooth-lined	Type IIA
Arch, spiral rib	Type IIR

Provide corrugated metal pipe of all types with annular corrugations, helical corrugations, or spiral ribs (corrugations) projecting outward. Provide pipe with helical end corrugations only when necessary to join new pipe to existing pipe with helical end corrugations.

Provide a minimum polymer coating thickness of 10 mils on each side for pre-coated galvanized steel pipe. Galvanized metal sheets and coils used for galvanized corrugated metal pipe may be sampled and tested in accordance with Tex-708-I.

Repair damaged galvanized coating in accordance with Section 445.3.5., “Repairs.” Repair damaged aluminized or polymer coating in accordance with AASHTO M 36 and M 245 respectively.

2.2. **Protective Coating**. Furnish bituminous coating, when required, that meets AASHTO M 190 and that tightly adheres to the metal, does not chip off in handling, and protects the pipe from deterioration as evidenced by samples prepared from the coating material successfully meeting the Shock Test and Flow Test in accordance with Tex-522-C.

Coat the pipe uniformly inside and out to a minimum thickness of 0.05 in. measured on the crests of the corrugations. Coat the pipe with additional material applied to the full inner circumference to form a smooth inside lining with a minimum thickness of 1/8 in. above the crest of the corrugations when smooth lining is specified.

2.3. **Design**. The diameter, permissible corrugations, and required gauges for full-circle pipe will be shown. The design size and permissible corrugations for pipe arch will be shown. The required gauges of the shell and the liner for smooth lined pipe will also be shown. Furnish the shape and minimum gauge for steel pipe arch in accordance with Tables 3, 4, 5, or 6 for the specified design size and corrugation. Use Table 7 or 8 for aluminum pipe arch. Refer to U.S. Standard Gauge for uncoated sheets where reference is made to gauge of metal.

Measure dimensions from the inside crests of the corrugations. A tolerance of ±1 in. or 2% of the equivalent circular diameter, whichever is greater, is allowed for span and rise.

Table 3
Steel Pipe Arch
2-2/3 × 1/2-in. Corrugations

Design Size	Span (in.)	Rise (in.)	Min Cover (in.)	Min Gauge Required	Coated Thickness (in.)	Equivalent Diameter Full-Circle Pipe (in.)
1	17	13	12	16	0.064	15
2	21	15	12	16	0.064	18
2A	23	19	12	16	0.064	21
3	28	20	12	16	0.064	24
4	35	24	12	16	0.064	30
5	42	29	12	14	0.079	36
6	49	33	12	14	0.079	42
7	57	38	12	12	0.109	48
8	64	43	12	12	0.109	54
9	71	47	12	10	0.138	60

Table 4
Steel Pipe Arch
3 × 1-in. Corrugations

Design Size	Span (in.)	Rise (in.)	Min Cover (in.)	Min Gauge Required	Coated Thickness (in.)	Equivalent Diameter Full-Circle Pipe (in.)
7	53	41	12	14	0.079	48
8	60	46	12	14	0.079	54
9	66	51	12	14	0.079	60
10	73	55	12	14	0.079	66
11	81	59	12	14	0.079	72
12	87	63	12	14	0.079	78
13	95	67	12	12	0.109	84
14	103	71	18	12	0.109	90
15	112	75	18	12	0.109	96
16	117	79	18	12	0.109	102
17	128	83	24	10	0.138	108
18	137	87	24	10	0.138	114
19	142	91	24	10	0.138	120

Table 5
Steel Pipe Arch
5 × 1-in. Corrugations

Design Size	Span (in.)	Rise (in.)	Min Cover (in.)	Min Gauge Required	Coated Thickness (in.)	Equivalent Diameter Full-Circle Pipe (in.)
11	81	59	12	12	0.109	72
12	87	63	12	12	0.109	78
13	95	67	12	12	0.109	84
14	103	71	18	12	0.109	90
15	112	75	18	12	0.109	96
16	117	79	18	12	0.109	102
17	128	83	24	10	0.138	108
18	137	87	24	10	0.138	114
19	142	91	24	10	0.138	120

Table 6
Steel Pipe Arch, Spiral Rib
7-1/2 × 3/4 × 3/4-in. Corrugations

Design Size	Span (in.)	Rise (in.)	Min Cover (in.)	Min Gauge Required	Coated Thickness (in.)	Equivalent Diameter Full-Circle Pipe (in.)
2	20	16	12	16	0.064	18
2A	23	19	12	16	0.064	21
3	27	21	12	16	0.064	24
4	33	26	12	16	0.064	30
5	40	31	12	14	0.064	36
6	46	36	12	12	0.064	42
7	53	41	12	12	0.079	48
8	60	46	12	12	0.079	54
9	66	51	15	12	0.079	60

Table 7
Aluminum Pipe Arch
2-2/3 × 1/2-in. Corrugations

Design Size	Span (in.)	Rise (in.)	Min Cover (in.)	Min Gauge Required	Coated Thickness (in.)	Equivalent Diameter Full-Circle Pipe (in.)
1	17	13	12	16	0.060	15
2	21	15	12	16	0.060	18
2A	23	19	12	16	0.060	21
3	28	20	12	14	0.075	24
4	35	24	12	14	0.075	30
5	42	29	18	12	0.105	36
6	49	33	18	12	0.105	42
7	57	38	18	10	0.135	48
8	64	43	18	10	0.135	54
9	71	47	18	8	0.164	60

Table 8
Aluminum Pipe Arch, Spiral Rib
7-1/2 × 3/4 × 3/4-in. Corrugations

Design Size	Span (in.)	Rise (in.)	Min Cover (in.)	Min Gauge Required	Coated Thickness (in.)	Equivalent Diameter Full-Circle Pipe (in.)
2	20	16	12	16	0.064	18
2A	23	19	12	16	0.064	21
3	27	21	15	16	0.064	24
4	33	26	18	16	0.064	30
5	40	31	18	14	0.075	36
6	46	36	18	12	0.105	42
7	53	41	21	12	0.105	48
8	60	46	18	10	0.135	54
9	66	51	21	10	0.135	60

2.4. **Coupling Bands**. Furnish coupling bands and other hardware for galvanized or aluminized steel pipe in accordance with AASHTO M 36 for steel pipe and AASHTO M 196 for aluminum pipe. Use coupling bands that are no more than 3 nominal sheet thicknesses lighter than the thickness of the pipe to be connected or no lighter than 0.052 in. for steel or 0.048 in. for aluminum. Provide coupling bands made of the same base metal and coating as the pipe.

3. CONSTRUCTION

3.1. **Designation of Type**. The types of pipes will be indicated on the plans by the following descriptions:

- Pipe type: Corrugated metal pipe (CMP), corrugated metal pipe arch (CMP ARCH), spiral rib corrugated metal pipe (SRCMP), or spiral rib corrugated metal pipe arch (SRCMP ARCH);
- Type of material: Galvanized steel, aluminum-coated (Type 2), or aluminum;
- Pipe coating: Bituminous coated or polymer coated;
- Special requirements: Paved invert or smooth lining; and
- Pipe size: Diameter or design number.

Furnish any of the material types specified above when pipe is designated as “Corrugated Metal Pipe” without a type of material or pipe coating designation.

3.2. **Excavation, Shaping, Bedding, and Backfill**. Excavate, shape, bed, and backfill in accordance with Item 400, “Excavation and Backfill for Structures,” except where jacking, boring, or tunneling methods are shown on the plans or permitted. Jack, bore, or tunnel in accordance with Item 476, “Jacking, Boring, or Tunneling Pipe or Box.”

Provide uniform backfill material and uniformly compacted density throughout the length of the structure so equal pressure is provided. Allow no heavy earth-moving equipment over the structure until a minimum of 4 ft. of compacted fill (permanent or temporary) has been placed over the top of the structure unless otherwise shown on the plans or permitted in writing. Inspect the inside periphery of the structure for local or unequal deformation caused by improper construction methods before adding each new layer of loose backfill material. Continue inspections until a minimum of 24 in. of cover is obtained. Evidence of such deformation will be reason for corrective measures as directed. Remove and replace pipe damaged by the Contractor at no additional cost to the Department.

3.3. **Laying Pipe**. Lay pipes on the bedding from the outlet end and join the separate sections firmly together with outside laps of annular joints pointing upstream and longitudinal laps on the sides unless otherwise authorized. Coat any metal in joints not protected by galvanizing or aluminizing with a suitable asphalt paint. Lower sections of pipe into the trench without damaging the pipe or disturbing the bedding and the sides of the trench. Remove and re-lay, without extra compensation, pipe that is not in alignment or shows excessive settlement after laying.

Lay multiple installations of corrugated metal pipe and pipe arches with the centerlines of individual barrels parallel. Maintain the clear distances between outer surfaces of adjacent pipes given in Table 9 unless otherwise indicated on the plans.

Table 9
Required Pipe Clear Distances

Diameter Full-Circle Pipe (in.)	Pipe Arch Design Size	Clear Distance Between Pipes (Full-Circle Pipe and Pipe Arch)
18	2	1 ft. 2 in.
21	2A	1 ft. 3 in
24	3	1 ft. 5 in.
30	4	1 ft. 8 in.
36	5	1 ft. 11 in.
42	6	2 ft. 2 in.
48	7	2 ft. 5 in.
54	8	2 ft. 10 in.
60 to 84	9	3 ft. 2 in.
90 to 120	10 and over	3 ft. 5 in.

3.4. **Jointing**. Provide field joints that maintain pipe alignment during construction and prevent infiltration of side material during the life of the installation. Provide one of the following jointing systems unless otherwise shown on the plans.

3.4.1. **Coupling Bands**. Use coupling bands with annular corrugations only with pipe with annular corrugations or with helical pipe or spiral rib pipe in which the ends have been rerolled to form annular corrugations. Provide bands with corrugations that have the same dimensions as the corrugations in the pipe end or are designed to engage the first or second corrugation from the end of each pipe. The band may also include a U-shaped channel to accommodate upturned flanges on the pipe.

Field-join pipe with helically corrugated bands or bands with projections (dimples) when helical end corrugations are allowed.

Coupling bands with projections may be used with pipe that has annular or helical end corrugations or spiral ribs. Provide bands formed with the projections in annular rows with 1 projection for each corrugation of helical pipe or spiral rib pipe. Provide 2 annular rows for bands 10-1/2 in. or 12 in. wide and 4 annular rows of projections for bands 16-1/2 in. or 22 in. wide.

Use a coupling band width that conforms to Table 10. Connect the bands using suitable galvanized devices in accordance with AASHTO M 36. Lap coupling bands equally on each of the pipes to form a tightly closed joint after installation. Provide at least the minimum coupling band width recommended by the manufacturer for corrugations not shown in Table 10.

Table 10
Coupling Band Width Requirements

Nominal Corrugation Size[1] (in.)	Nominal Pipe Inside Diameter[2] (in.)	Minimum Coupling Band Width (in.)		
		Annular Corrugated Bands	Helically Corrugated Bands	Bands with Projections
2-2/3 by 1/2	12 to 36	7	12	10-1/2
	42 to 72	10-1/2	12	10-1/2
	78 to 84[3]	10-1/2	12	16-1/4
3 by 1	36 to 72	12	14	10-1/2
	78 to 120	12	14	16-1/4
5 by 1	36 to 72	20	22	12
	78 to 120	20	22	22
7-1/2 by 3/4 by 3/4	18 to 60	10-1/2	12	10-1/2
	66 to 102	10-1/2	12	16-1/4

1. For helically corrugated pipe or spiral rib pipe with rerolled ends, the nominal size refers to the dimensions of the end corrugations in the pipe.
2. Equivalent circular diameter for Type II pipe.
3. Diameter through 120 in. for annular corrugated bands used on rerolled ends of helically corrugated pipe or spiral rib pipe.

The minimum diameter of bolts for coupling bands is 3/8 in. for pipe diameters 18 in. and less and 1/2 in. for pipe diameters 21 in. and greater. Provide at least 2 bolts for bands 12 in. wide or less. Provide at least 3 bolts for bands wider than 12 in.

Provide galvanized hardware in accordance with Item 445, “Galvanizing.”

3.4.2. **Bell and Spigot**. Attach the bell to one end of the corrugated metal pipe at the manufacturing plant before shipment. Provide a bell with a minimum 6-in. stab depth. Install the gasket on the spigot end and apply lubricant in accordance with the manufacturer’s recommendations. Provide gaskets that meet ASTM F477 with Type A Shore durometer hardness of 45 ±5. Do not use thermoplastic elastomer as the basic polymer. Push the spigot end of the pipe into the bell end of the previously laid pipe during laying of the pipe.

3.4.3. **Pipe Connections and Stub Ends**. Make connections of pipe to existing pipe or appurtenances as shown on the plans or as directed. Mortar or concrete the bottom of the existing structure, if necessary, to eliminate any drainage pockets created by the new connection.

Insulate portions of aluminum pipe that are to be in contact with metal other than aluminum by a coating of bituminous material meeting the requirements of Section 460.2.2., “Protective Coating.” Extend the coating a minimum of 1 ft. beyond the area of contact.

Restore any damage that results from making the connection when connecting pipe into existing structures that will remain in service. Seal stub ends for connections to future work not shown on the plans by installing watertight plugs into the free end of the pipe.

4. MEASUREMENT

This Item will be measured by the foot. Pipe will be measured between the ends of the barrel along the flow line, not including safety end treatments. Safety end treatments will be measured in accordance with Item 467, “Safety End Treatment.” Pipe that is required to be jacked, bored, or tunneled will be measured in accordance with Item 476, “Jacking, Boring, or Tunneling Pipe or Box.” Where spurs, branches, or connections to existing pipe lines are involved, measurement of the spur or new connecting pipe will be made from the intersection of the flow line with the outside surface of the pipe into which it connects. Where inlets, headwalls, catch basins, manholes, junction chambers, or other structures are included in lines of pipe, the length of pipe tying into the structure wall will be included for measurement but no other portion of the structure length or width will be included.

For multiple pipes, the measured length will be the sum of the lengths of the barrels.

This is a plans quantity measurement Item. The quantity to be paid is the quantity shown in the proposal, unless modified by Article 9.2., “Plans Quantity Measurement.” Additional measurements or calculations will be made if adjustments of quantities are required.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for “Corrugated Metal Pipe,” “Corrugated Metal Pipe Arch,” “Spiral Rib Corrugated Metal Pipe,” or “Spiral Rib Corrugated Metal Pipe Arch” of the type, size, and coating specified. This price is full compensation for furnishing, hauling, placing, and joining of pipes; jointing materials; all connections to new or existing structures; breaking back, removing, and disposing of portions of the existing structure; replacing portions of the existing structure; cutting pipe ends on skew or slope; and equipment, labor, tools, and incidentals.

Protection methods for excavations greater than 5 ft. deep will be measured and paid for as required under Item 402, “Trench Excavation Protection,” or Item 403, “Temporary Special Shoring.” Excavation, shaping, bedding, and backfill will be paid for in accordance with Item 400, “Excavation and Backfill for Structures.” When jacking, boring, or tunneling is used at the Contractor’s option, payment will be made under this Item. When jacking, boring, or tunneling is required, payment will be made under Item 476, “Jacking, Boring, or Tunneling Pipe or Box.”

Item 462
Concrete Box Culverts and Drains

1. DESCRIPTION

Furnish, construct, and install concrete box culverts and drains.

2. MATERIALS

2.1. **General**. Furnish materials in accordance with the following.

- Item 420, "Concrete Substructures,"
- Item 421, "Hydraulic Cement Concrete,"
- Item 440, "Reinforcement for Concrete," and
- Item 464, "Reinforced Concrete Pipe."

Provide cast-in-place or precast, formed or machine-made, box culverts, and drains. Use Class S concrete for top slabs of cast-in-place concrete culverts for culverts with overlay, a 1- to 2-course surface treatment or a top slab that is the final riding surface unless otherwise shown on the plans. Use Class C concrete for the rest of the culvert and for all other cast-in-place boxes. Culverts with fill do not require Class S concrete.

Furnish material for machine-made precast boxes in accordance with DMS-7310, "Reinforced Concrete Pipe and Machine-Made Precast Concrete Box Culvert Fabrication and Plant Qualification."

2.2. **Fabrication**.

2.2.1. **Cast-in-Place**. Meet Item 420, "Concrete Substructures" and Item 422, "Concrete Superstructures."

2.2.2. **Formed Precast**. Meet Item 424, "Precast Concrete Structural Members (Fabrication)."

2.2.3. **Machine-Made Precast**. Machine-made precast box culvert fabrication plants must be approved in accordance with DMS-7310, "Reinforced Concrete Pipe and Machine-Made Precast Concrete Box Culvert Fabrication and Plant Qualification." The Department's MPL shows approved machine-made precast box culvert plants. Fabricate machine-made precast boxes in accordance with DMS-7310, "Reinforced Concrete Pipe and Machine-Made Precast Concrete Box Culvert Fabrication and Plant Qualification."

2.3. **Testing**.

2.3.1. **Cast-in-Place**. Provide test specimens that meet Item 421, "Hydraulic Cement Concrete."

2.3.2. **Formed Precast**. Make, cure, and test compressive test specimens in accordance with Tex-704-I.

2.3.3. **Machine-Made Precast**. Make, cure, and test compressive test specimens in accordance with DMS-7310, "Reinforced Concrete Pipe and Machine-Made Precast Concrete Box Culvert Fabrication and Plant Qualification."

2.3.4. **Testing Equipment**. The producer must furnish all equipment required for testing concrete for boxes produced in a precasting plant.

2.4. **Lifting Holes**. Provide no more than 4 lifting holes in each section for precast boxes. Lifting holes may be cast, cut into fresh concrete after form removal, or drilled. Provide lifting holes large enough for adequate

lifting devices based on the size and weight of the box section. Use lifting holes no larger than 3 in. in diameter. Cut no more than 5 in. in any direction of reinforcement per layer for lifting holes.

2.5. **Marking**. Mark precast boxes with the following:

- name or trademark of fabricator and plant location;
- ASTM designation;
- date of manufacture;
- box size;
- minimum and maximum fill heights;
- designated fabricator's approval stamp;
- boxes to be used for jacking and boring (when applicable);
- designation "SR" for boxes meeting sulfate-resistant concrete plan requirements (when applicable); and
- match-marks for proper installation, when required under Section 462.2.6., "Tolerances."

Mark 1 end of each box section, for boxes without lifting holes, on the inside and outside walls to indicate the top or bottom as it will be installed.

Indent markings into the box section or paint them on each box with waterproof paint.

2.6. **Tolerances**. Ensure precast sections meet the permissible variations listed in ASTM C1577 and that the sides of a section at each end do not vary from being perpendicular to the top and bottom by more than 1/2 in. when measured diagonally between opposite interior corners.

Ensure wall and slab thicknesses are not less than shown on the plans except for occasional deficiencies not greater than 3/16 in. or 5%, whichever is greater. If proper jointing is not affected, thicknesses in excess of plan requirements are acceptable.

Deviations from the above tolerances will be acceptable if the sections can be fitted at the plant or jobsite and the joint opening at any point does not exceed 1 in. Use match-marks for proper installation on sections that have been accepted in this manner.

2.6.1. **Boxes for Jacking Operations**. Use boxes for jacking operations as defined in Item 476, "Jacking, Boring, or Tunneling Pipe or Box," meeting the following additional requirements:

- The box ends must be square such that no point deviates more than 3/8 in. from a plane placed on the end of the box that is perpendicular to the box sides, and
- The slab and wall thicknesses must not be less than specified on the plans and must not exceed the specified thickness by more than 1/2 in.

2.7. **Defects and Repair**. Fine cracks on the surface of the member that do not extend to the plane of the nearest reinforcement are acceptable unless the cracks are numerous and extensive. Repair cracks that extend into the plane of the reinforcing steel in an approved manner. Excessive damage, honeycomb, or cracking will be subject to structural review. The Engineer may accept boxes with repairs that are sound, properly finished, and cured in conformance with pertinent specifications. Discontinue further production of precast sections when fine cracks on the surface indicate poor curing practices until corrections are made and proper curing is provided.

Repair machine-made precast boxes in accordance with DMS-7310, "Reinforced Concrete Pipe and Machine-Made Precast Concrete Box Culvert Fabrication and Plant Qualification."

2.8. **Storage and Shipment**. Store precast sections on a level surface. Do not place any load on the sections until design strength is reached and curing is complete. Shipment of sections is permissible when the design strength and curing requirements have been met.

Store and ship machine-made precast boxes in accordance with DMS-7310, "Reinforced Concrete Pipe and Machine-Made Precast Concrete Box Culvert Fabrication and Plant Qualification."

3. CONSTRUCTION

3.1. **Excavation, Shaping, Bedding, and Backfill**. Excavate, shape, bed, and backfill in accordance with Item 400, "Excavation and Backfill for Structures," except where jacking, boring, or tunneling methods are shown on the plans or permitted. Jack, bore, or tunnel in accordance with Item 476, "Jacking, Boring, or Tunneling Pipe or Box." Immediate backfilling is permitted for all box structures where joints consist of materials other than mortar. Take precautions in placing and compacting the backfill to avoid any movement of the boxes or damage to the joints. Remove and replace boxes damaged by the Contractor at no expense to the Department.

3.2. **Placement of Boxes**. Place the box sections in conformance with the plans or as directed when precast boxes are used to form multiple barrel structures. Place material to be used between barrels as shown on the plans or as directed. Start the laying of boxes on the bedding at the outlet end and proceed toward the inlet end with the abutting sections properly matched unless otherwise authorized. Fit, match, and lay the boxes to form a smooth, uniform conduit true to the established lines and grades. Lower the box sections into the trench, for trench installations, without damaging the box or disturbing the bedding and the sides of the trench. Carefully clean the ends of the box before it is placed. Prevent the earth or bedding material from entering the box as it is laid. Remove and re-lay, without extra compensation, boxes that are not in alignment or show excessive settlement after laying. Form and place cast-in-place boxes in accordance with Item 420, "Concrete Substructures."

3.3. **Jointing**. Use any of the jointing materials in accordance with the joint requirements specified in Item 464, "Reinforced Concrete Pipe," unless otherwise shown on the plans. Box joints for rubber gasketed material may be substituted for tongue and groove joints, provided they meet the requirements of ASTM C1677 for design of the joints and permissible variations in dimensions.

3.4. **Connections and Stub Ends**. Make connections of boxes to existing boxes, pipes, drains, or drain appurtenances as shown on the plans. Mortar or concrete the bottom of existing structures if necessary to eliminate any drainage pockets created by the connections. Connect boxes to any required headwalls, wingwalls, safety end treatments or riprap, or other structures as shown on the plans or as directed. Repair any damage to the existing structure resulting from making the connections. Finish stub ends for connections to future work not shown on the plans by installing watertight plugs into the free end of the box.

Fill lifting holes with mortar or concrete and cure for precast boxes. Precast concrete or mortar plugs may be used.

3.5. **Extending**. Break back and extend existing culverts in accordance with Section 420.4.8 "Extending Existing Substructures," and Section 422.4.5 "Extending Existing Slabs," as applicable.

4. MEASUREMENT

This Item will be measured by the foot. Measurement will be made between the ends of the culvert or drain along the flow line, not including safety end treatments. Safety end treatments will be measured in accordance with Item 467, "Safety End Treatment." Measurement of spurs, branches, or new connection box section will be made from the intersection of the flow line with the outside surface of the structure into which it connects. Where inlets, headwalls, wingwalls, catch basins, manholes, junction chambers, or other structures are included in lines of culverts or drains, the length of box section tying into the structure wall will be included for measurement, but no other portion of the structure length or width will be included.

The measured length of multiple barrel structures will be the sum of the lengths of the barrels.

This is a plans quantity measurement Item. The quantity to be paid is the quantity shown in the proposal unless modified by Article 9.2., "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Concrete Box Culvert" of the size specified. This price is full compensation for constructing, furnishing, and transporting sections; preparation and shaping of the bed; backfill material between box sections; jointing of sections; jointing material; cutting of sections on skew or slope; connections to new or existing structures; breaking back, removing and disposing of portions of the existing structure and replacing portions of the existing structure as required to make connections; concrete and reinforcing steel; and equipment, labor, materials, tools, and incidentals.

Protection methods for excavations greater than 5 ft. deep will be measured and paid for as required under Item 402, "Trench Excavation Protection," or Item 403, "Temporary Special Shoring." Excavation, shaping, bedding, and backfill will be paid for in accordance with Item 400, "Excavation and Backfill for Structures." When jacking, boring, or tunneling is used at the Contractor's option, payment will be made under this Item. When jacking, boring, or tunneling is required, payment will be made under Item 476, "Jacking, Boring, or Tunneling Pipe or Box."

Item 466
Headwalls and Wingwalls

1. DESCRIPTION

Furnish, construct, and install concrete headwalls and wingwalls for drainage structures and underpasses.

2. MATERIALS

2.1. **General**. Furnish materials in accordance with the following.

- Item 420, "Concrete Substructures,"
- Item 421, "Hydraulic Cement Concrete," and
- Item 440, "Reinforcement for Concrete."

Use Class C concrete for cast-in-place and precast concrete units unless otherwise shown on the plans. Furnish cast-in-place or precast headwalls and wingwalls unless otherwise shown on the plans.

2.2. **Fabrication**.

2.2.1. **General**. Fabricate cast-in-place concrete units and precast units in accordance with Item 420 "Concrete Substructures." Use the following definitions for headwalls and wingwalls:

- "Headwalls" refers to all walls, including wings, at the ends of single-barrel and multiple-barrel pipe culvert structures.
- "Wingwalls" refers to all walls at the ends of single-barrel or multiple-barrel box culvert structures.

2.2.2. **Lifting Holes**. Provide no more than 4 lifting holes in each section for precast units. Lifting holes may be cast, cut into fresh concrete after form removal, or drilled. Provide lifting holes large enough for adequate lifting devices based on the size and weight of the section. The maximum hole diameter is 3 in. at the inside surface of the wall and 4 in. at the outside surface. Cut no more than 1 longitudinal wire or 2 circumferential wires per layer of reinforcing steel when locating lift holes. Repair spalled areas around lifting holes.

2.2.3. **Marking**. Clearly mark each precast unit before shipment from the casting or fabrication yard with the following:

- the date of manufacture,
- the name or trademark of the manufacturer, and
- the type and size designation.

2.2.4. **Storage and Shipment**. Store precast units on a level surface. Do not place any loads on precast concrete units until design strength is reached. Do not ship units until design strength requirements have been met.

2.2.5. **Causes for Rejection**. Precast units may be rejected for not meeting any one of the specification requirements. Individual units may also be rejected for fractures or cracks passing through the wall or surface defects indicating honeycombed or open texture surfaces. Remove rejected units from the project, and replace them with acceptable units meeting the requirements of this Item.

2.2.6. **Defects and Repairs**. Occasional imperfections in manufacture or accidental damage sustained during handling may be repaired. The repaired units will be acceptable if they conform to the requirements of this Item and the repairs are sound, properly finished, and cured in conformance with pertinent specifications.

3. CONSTRUCTION

3.1. **General**. Remove portions of existing structures and drill, dowel, and grout in accordance with Item 420, "Concrete Substructures."

3.2. **Excavation, Shaping, Bedding, and Backfill**. Excavate, shape, bed, and backfill in accordance with Item 400, "Excavation and Backfill for Structures." Take special precautions in placing and compacting the backfill to avoid any movement or damage to the units. Bed precast units on foundations of firm and stable material accurately shaped to conform to the bases of the units.

3.3. **Placement of Precast Units**. Provide adequate means to lift and place the precast units. Fill lifting holes with mortar or concrete and cure. Precast concrete or mortar plugs may be used.

3.4. **Connections**. Make connections to new or existing structures in accordance with the details shown on the plans. Furnish jointing material in accordance with Item 464, "Reinforced Concrete Pipe," or as shown on the plans.

Remove a length of the existing pipe from the headwall to the joint when removing existing headwalls as shown on the plans or as approved. Re-lay the removed pipe if approved, or furnish and lay a length of new pipe.

4. MEASUREMENT

This is a plans quantity measurement item. The quantity to be paid is the quantity shown in the proposal unless modified by Article 9.2., "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.

4.1. **Headwalls**. Headwalls will be measured by each end of a structure.

4.2. **Wingwalls**. Wingwalls will be measured by one of the following methods:

4.2.1. **Square Foot**. Wingwalls will be measured by the square foot of the front surface area of the wall of each type. The area will be measured from the top of the footing or apron to the top of the wall unless otherwise shown on the plans. If there is no footing or apron, then measurement is from the bottom of the wall.

4.2.2. **Each**. Wingwalls will be measured by each end of a structure.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the price bid for "Headwalls" of the type and pipe size (diameter or design) specified, "Wingwalls" of the type specified when measurement is by the square foot, or "Wingwalls" of the type and wall height specified when measurement is by each. For payment purposes, the wingwall height will be rounded to the nearest foot. All wingwalls and headwalls of the same type will be paid for equally when skew does not affect the type. This price is full compensation for constructing, furnishing, transporting, and installing the headwalls or wingwalls; connecting to existing structure; breaking back, removing and disposing of portions of the existing structure, and replacing portions of the existing structure as required to make connections; excavation and backfill; and concrete, reinforcing steel, corrugated metal pipe or reinforced concrete pipe, equipment, labor, tools, and incidentals.

Apron concrete or riprap between or around the wingwalls of single- or multiple-barrel box culvert structures will be measured and paid for in accordance with Item 432, "Riprap."

The removal and re-laying of existing pipe or the furnishing of new pipe to replace existing pipe will not be paid for directly but will be considered subsidiary to this Item.

Item 472
Removing and Re-Laying Culvert

1. DESCRIPTION

Remove, transport, clean, and re-lay existing culvert and storm drain pipe.

2. MATERIALS

Bituminous coating must meet the requirements of Section 460.2.2., "Protective Coating."

3. CONSTRUCTION

Culvert and storm drain pipe to be removed and re-laid will be shown on the plans. Remove debris and sediment within the culvert and storm drain pipe. Clean joints to facilitate proper re-laying. Install concrete pipe in accordance with Item 464, "Reinforced Concrete Pipe." Install corrugated metal pipe in accordance with Item 460, "Corrugated Metal Pipe." Excavate, bed, and backfill in accordance with Item 400, "Excavation and Backfill for Structures." Prevent damage to the pipe and fittings. Make connections to existing structures as shown on the plans and in conformance to the requirements for connections as described in pertinent pipe specifications. Connect reinforced concrete pipe to corrugated metal pipe with a suitable concrete collar with a minimum thickness of 4 in. or as shown on the plans. Use a coating of bituminous material to insulate portions of aluminum pipe that are to be in contact with metal other than aluminum. Extend coating at least 1 ft. beyond area of contact. Mark the top and bottom of reinforced concrete pipe before removal and reinstall in the same position. Reuse headwall, aprons, or other appurtenances by severing from the culvert and moving to the new position if shown on the plans. Make connections for joining sections of pipes in accordance with pertinent Items.

Replace any items designated for reuse with new material or restore them to previous condition, as approved. The Contractor may remove and dispose of existing structures and construct new structures at no expense to the Department in accordance with pertinent specifications and designs shown on the plans or as approved.

4. MEASUREMENT

This Item will be measured by the foot between the ends of the pipe barrel along the flow line as installed. Where spurs, branches, or connections to the existing pipe lines are involved, measurement of the spur or connecting pipe will be made from the intersection at the flow line with the outside surface of the pipe into which the pipe connects. Where inlets, catch basins, manholes, safety end treatments, or other structures are included in lines of pipe, the length of pipe tying into the structure wall will be included for measurement but no other portion of the structure length or width will be included.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measurement as provided under "Measurement" will be paid for at the unit price bid for "Removing and Re-laying Pipe" of the size specified. This price is full compensation for excavating and removing pipe from its original location; loading, hauling, placing, and joining pipe; cutting pipe ends on skew or slope; moving and re-using headwalls and safety end treatments; connections to existing structures; concrete collars and reinforcing; and equipment, materials, labor, tools, and incidentals. Removal and disposal of pipe and appurtenances not reused will be subsidiary to the bid items of the Contract. Protection methods for excavations greater than 5 ft. in depth will be measured and paid for as required under Item 402, "Trench Excavation Protection," or Item 403,

"Temporary Special Shoring." Excavation, bedding, and backfill for re-laying pipe will be paid for in accordance with Item 400, "Excavation and Backfill for Structures." When jacking, boring, or tunneling is used at the Contractor's option, payment will be made under this Item. When jacking, boring, or tunneling is required, payment will be made under Item 476, "Jacking, Boring, or Tunneling Pipe or Box."

Item 480
Cleaning Existing Culverts

1. DESCRIPTION

Remove all extraneous material from existing culvert barrels and pipes.

2. WORK METHODS

Expose all inside surfaces of the specified culverts. Do not move or damage the culvert. Dispose of material in accordance with federal, state, and local regulations. Place on roadway slopes when approved.

Perform cleaning to maintain drainage during construction. Acceptance of the cleaned culverts occurs at final acceptance of the project in accordance with Article 5.11., “Final Cleanup,” unless otherwise shown on the plans.

3. MEASUREMENT

This Item will be measured by each complete culvert cleaned regardless of the number of barrels or pipes at each location or by the cubic yard. If measurement is by the cubic yard, the volume of material to be removed will be computed by the method of average end areas in its original position.

4. PAYMENT

The work performed in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for “Cleaning Existing Culverts.” This price is full compensation for excavation, disposal of excavated material, equipment, labor, tools, and incidentals.

Item 500
Mobilization

1. DESCRIPTION

Establish and remove offices, plants, and facilities. Move personnel, equipment, and supplies to and from the project or the vicinity of the project site to begin work or complete work on Contract Items. Bonds and insurance are required for performing mobilization.

For Contracts with emergency mobilization, provide a person and method of contact available 24 hrs. a day, 7 days a week unless otherwise shown on the plans. The time of notice will be the transmission time of the written notice or notice provided orally by the Department's representative.

2. MEASUREMENT

This Item will be measured by the lump sum or each as the work progresses. Mobilization is calculated on the base bid only and will not be paid for separately on any additive alternate items added to the Contract.

3. PAYMENT

For this Item, the adjusted Contract amount will be calculated as the total Contract amount less the lump sum for mobilization. Except for Contracts with callout or emergency work, mobilization will be paid in partial payments as follows:

- Payment will be made upon presentation of a paid invoice for the payment or performance bonds and required insurance,
- Payment will be made upon verification of documented expenditures for plant and facility setup. The combined amount for all these facilities will be no more than 10% of the mobilization lump sum or 1% of the total Contract amount, whichever is less,
- When 1% of the adjusted Contract amount for construction Items is earned, 50% of the mobilization lump sum bid or 5% of the total Contract amount, whichever is less, will be paid. Previous payments under this Item will be deducted from this amount,
- When 5% of the adjusted Contract amount for construction Items is earned, 75% of the mobilization lump sum bid or 10% of the total Contract amount, whichever is less, will be paid. Previous payments under the Item will be deducted from this amount,
- When 10% of the adjusted Contract amount for construction Items is earned, 90% of the mobilization lump sum bid or 10% of the total Contract amount, whichever is less, will be paid. Previous payments under this Item will be deducted from this amount,
- Upon final acceptance, 97% of the mobilization lump sum bid will be paid. Previous payments under this Item will be deducted from this amount, and
- Payment for the remainder of the lump sum bid for "Mobilization" will be made after all submittals are received, final quantities have been determined and when any separate vegetative establishment and maintenance, test, and performance periods provided for in the Contract have been successfully completed.

For projects with extended maintenance or performance periods, payment for the remainder of the lump sum bid for "Mobilization" will be made 6 months after final acceptance.

For Contracts with callout or emergency work, “Mobilization,” will be paid as follows:

- Payment will be made upon presentation of a paid invoice for the payment of performance bonds and required insurance,
- Mobilization for callout work will be paid for each callout work request, and
- Mobilization for emergency work will be paid for each emergency work request.

Item 502
Barricades, Signs, and Traffic Handling

1. DESCRIPTION

Provide, install, move, replace, maintain, clean, and remove all traffic control devices shown on the plans and as directed.

2. CONSTRUCTION

Comply with the requirements of Article 7.2., "Safety."

Implement the traffic control plan (TCP) shown on the plans.

Install traffic control devices straight and plumb. Make changes to the TCP only as approved. Minor adjustments to meet field conditions are allowed.

Submit Contractor-proposed TCP changes, signed and sealed by a licensed professional engineer, for approval. The Engineer may develop, sign, and seal Contractor-proposed changes. Changes must conform to guidelines established in the TMUTCD using approved products from the Department's Compliant Work Zone Traffic Control Device List.

Maintain traffic control devices by taking corrective action when notified. Corrective actions include, but are not limited to, cleaning, replacing, straightening, covering, and removing devices. Maintain the devices such that they are properly positioned and spaced, legible, and have retroreflective characteristics that meet requirements day or night and in all weather conditions.

The Engineer may authorize or direct in writing the removal or relocation of project limit advance warning signs. When project limit advance warning signs are removed before final acceptance, provide traffic control in accordance with the TMUTCD for minor operations as approved.

Remove all traffic control devices upon completion of the work as shown on the plans or as directed.

3. MEASUREMENT

Barricades, Signs, and Traffic Handling will be measured by the month. Law enforcement personnel with patrol vehicles will be measured by the hour for each person.

4. PAYMENT

4.1. **Barricades, Signs, and Traffic Handling**. Except for Contracts with callout work and work orders, the work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Barricades, Signs, and Traffic Handling." This price is full compensation for installation, maintenance, adjustments, replacements, removal, materials, equipment, labor, tools, and incidentals.

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Barricades, Signs, and Traffic Handling." This price is full compensation for installation, maintenance, adjustments, replacements, removal, materials, equipment, labor, tools, and incidentals.

When the plans establish pay items for particular work in the TCP, that work will be measured and paid under pertinent Items.

4.1.1. **Initiation of Payment**. Payment for this Item will begin on the first estimate after barricades, signs, and traffic handling devices have been installed in accordance with the TCP and construction has begun.

4.1.2. **Paid Months**. Monthly payment will be made each succeeding month for this Item provided the barricades, signs, and traffic handling devices have been installed and maintained in accordance with the TCP until the Contract amount has been paid.

If, within the time frame established by the Engineer, the Contractor fails to provide or properly maintain signs and barricades in compliance with the Contract requirements, as determined by the Engineer, the Contractor will be considered in noncompliance with this Item. No payment will be made for the months in question, and the total final payment quantity will be reduced by the number of months the Contractor was in noncompliance.

4.1.3. **Maximum Total Payment Before Acceptance**. The total payment for this Item will not exceed 10% of the total Contract amount before final acceptance in accordance with Article 5.12., "Final Acceptance." The remaining balance will be paid in accordance with Section 502.4.1.5., "Balance Due."

4.1.4. **Total Payment Quantity**. The quantity paid under this Item will not exceed the total quantity shown on the plans except as modified by change order and as adjusted by Section 502.4.1.2., "Paid Months." An overrun of the plans quantity for this Item will not be allowed for approving designs; testing; material shortages; closed construction seasons; curing periods; establishment, performance, test, and maintenance periods; failure to complete the work in the number of months allotted; nor delays caused directly or indirectly by requirements of the Contract.

4.1.5. **Balance Due**. The remaining unpaid months of barricades less non-compliance months will be paid on final acceptance of the project, if all work is complete and accepted in accordance with Article 5.12., "Final Acceptance."

4.1.6. **Contracts with Callout Work and Work Orders**. The work performed and the materials furnished with this Item and measured as provided under "Measurement," will be considered subsidiary to pertinent Items, except for federally funded Contracts.

4.2. **Law Enforcement Personnel**. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement," will be paid by Contractor force account for "Law Enforcement Personnel." This price is full compensation for furnishing all labor, materials, supplies, equipment, patrol vehicle, fees, and incidentals necessary to complete the work as directed.

Item 506

Temporary Erosion, Sedimentation, and Environmental Controls

1. DESCRIPTION

Install, maintain, and remove erosion, sedimentation, and environmental control measures to prevent or reduce the discharge of pollutants in accordance with the Storm Water Pollution Prevention Plan (SWP3) on the plans and the Texas Pollutant Discharge Elimination System (TPDES) General Permit TXR150000. Control measures are defined as Best Management Practices used to prevent or reduce the discharge of pollutants. Control measures include, but are not limited to, rock filter dams, temporary pipe slope drains, temporary paved flumes, construction exits, earthwork for erosion control, pipe, construction perimeter fence, sandbags, temporary sediment control fence, biodegradable erosion control logs, vertical tracking, temporary or permanent seeding, and other measures. Erosion and sediment control devices must be selected from the *Erosion Control Approved Products* or *Sediment Control Approved Products* lists. Perform work in a manner to prevent degradation of receiving waters, facilitate project construction, and comply with applicable federal, state, and local regulations. Ensure the installation and maintenance of control measures is performed in accordance with the manufacturer's or designer's specifications.

Provide the Contractor Certification of Compliance before performing SWP3 or soil disturbing activities. By signing the Contractor Certification of Compliance, the Contractor certifies they have read and understand the requirements applicable to this project pertaining to the SWP3, the plans, and the TPDES General Permit TXR150000. The Contractor is responsible for any penalties associated with non-performance of installation or maintenance activities required for compliance. Ensure the most current version of the certificate is executed for this project.

2. MATERIALS

Furnish materials in accordance with the following:

- Item 161, "Compost,"
- Item 432, "Riprap," and
- Item 556, "Pipe Underdrains."

2.1. **Rock Filter Dams**.

2.1.1. **Aggregate**. Furnish aggregate with approved hardness, durability, cleanliness, and resistance to crumbling, flaking, and eroding. Provide the following:

- Types 1, 2, and 4 Rock Filter Dams. Use 3 to 6 in. aggregate.
- Type 3 Rock Filter Dams. Use 4 to 8 in. aggregate.

2.1.2. **Wire**. Provide minimum 20 gauge galvanized wire for the steel wire mesh and tie wires for Types 2 and 3 rock filter dams. Type 4 dams require:

- a double-twisted, hexagonal weave with a nominal mesh opening of 2-1/2 × 3-1/4 in.;
- minimum 0.0866 in. steel wire for netting;
- minimum 0.1063 in. steel wire for selvages and corners; and
- minimum 0.0866 in. for binding or tie wire.

2.1.3. **Sandbag Material**. Furnish sandbags meeting Section 506.2.8., "Sandbags," except that any gradation of aggregate may be used to fill the sandbags.

2.2. **Temporary Pipe Slope Drains**. Provide corrugated metal pipe, polyvinyl chloride (PVC) pipe, flexible tubing, watertight connection bands, grommet materials, prefabricated fittings, and flared entrance sections that conform to the plans. Recycled and other materials meeting these requirements are allowed if approved.

Furnish concrete in accordance with Item 432, "Riprap."

2.3. **Temporary Paved Flumes**. Furnish asphalt concrete, hydraulic cement concrete, or other comparable non-erodible material that conforms to the plans. Provide rock or rubble with a minimum diameter of 6 in. and a maximum volume of 1/2 cu. ft. for the construction of energy dissipaters.

2.4. **Construction Exits**. Provide materials that meet the details shown on the plans and this Section.

2.4.1. **Rock Construction Exit**. Provide crushed aggregate for long- and short-term construction exits. Furnish aggregates that are clean, hard, durable, and free from adherent coatings such as salt, alkali, dirt, clay, loam, shale, soft or flaky materials, and organic and injurious matter. Use 4- to 8-in. aggregate for Type 1. Use 2- to 4-in. aggregate for Type 3.

2.4.2. **Timber Construction Exit**. Furnish No. 2 quality or better railroad ties and timbers for long-term construction exits, free of large and loose knots and treated to control rot. Fasten timbers with nuts and bolts or lag bolts, of at least 1/2 in. diameter, unless otherwise shown on the plans or allowed. Provide plywood or pressed wafer board at least 1/2 in. thick for short-term exits.

2.4.3. **Foundation Course**. Provide a foundation course consisting of flexible base, bituminous concrete, hydraulic cement concrete, or other materials as shown on the plans or directed.

2.5. **Embankment for Erosion Control**. Provide rock, loam, clay, topsoil, or other earth materials that will form a stable embankment to meet the intended use.

2.6. **Pipe**. Provide pipe outlet material in accordance with Item 556, "Pipe Underdrains," and details shown on the plans.

2.7. **Construction Perimeter Fence**.

2.7.1. **Posts**. Provide essentially straight wood or steel posts that are at least 60 in. long. Furnish soft wood posts with a minimum diameter of 3 in., or use nominal 2 × 4 in. boards. Furnish hardwood posts with a minimum cross-section of 1-1/2 × 1-1/5 in. Furnish T- or L-shaped steel posts with a minimum weight of 1.25 lb. per foot.

2.7.2. **Fence**. Provide orange construction fencing as approved.

2.7.3. **Fence Wire**. Provide 14 gauge or larger galvanized smooth or twisted wire. Provide 16 gauge or larger tie wire.

2.7.4. **Flagging**. Provide brightly-colored flagging that is fade-resistant and at least 3/4 in. wide to provide maximum visibility both day and night.

2.7.5. **Staples**. Provide staples with a crown at least 1/2 in. wide and legs at least 1/2 in. long.

2.7.6. **Used Materials**. Previously used materials meeting the applicable requirements may be used if approved.

2.8. **Sandbags**. Provide sandbag material of polypropylene, polyethylene, or polyamide woven fabric with a minimum unit weight of 4 oz. per square yard, a Mullen burst-strength exceeding 300 psi, and an ultraviolet stability exceeding 70%.

Use natural coarse sand or manufactured sand meeting the gradation given in Table 1 to fill sandbags. Filled sandbags must be 24 to 30 in. long, 16 to 18 in. wide, and 6 to 8 in. thick.

Table 1
Sand Gradation

Sieve Size	Retained (% by Weight)
#4	Maximum 3%
#100	Minimum 80%
#200	Minimum 95%

Aggregate may be used instead of sand for situations where sandbags are not adjacent to traffic. The aggregate size must not exceed 3/8 in.

2.9. **Temporary Sediment Control Fence**. Provide a net-reinforced fence using woven geo-textile fabric. Logos visible to the traveling public will not be allowed.

2.9.1. **Fabric**. Provide fabric materials in accordance with DMS-6230, "Temporary Sediment Control Fence Fabric."

2.9.2. **Posts**. Provide essentially straight wood or steel posts with a minimum length of 48 in., unless otherwise shown on the plans. Furnish soft wood posts at least 3 in. in diameter, or use nominal 2 × 4 in. boards. Furnish hardwood posts with a minimum cross-section of 1-1/2 × 1-1/2 in. Furnish T- or L-shaped steel posts with a minimum weight of 1.25 lb. per foot.

2.9.3. **Net Reinforcement**. Provide net reinforcement of at least 12.5 gauge (SWG) galvanized welded wire mesh, with a maximum opening size of 2 × 4 in., at least 24 in. wide, unless otherwise shown on the plans.

2.9.4. **Staples**. Provide staples with a crown at least 3/4 in. wide and legs 1/2 in. long.

2.9.5. **Used Materials**. Use recycled material meeting the applicable requirements if approved.

2.10. **Biodegradable Erosion Control Logs**.

2.10.1. **Core Material**. Furnish core material that is biodegradable or recyclable. Use compost, mulch, aspen excelsior wood fibers, chipped site vegetation, agricultural rice or wheat straw, coconut fiber, 100% recyclable fibers, or any other acceptable material unless specifically called out on the plans. Permit no more than 5% of the material to escape from the containment mesh. Furnish compost meeting the requirements of Item 161, "Compost."

2.10.2. **Containment Mesh**. Furnish containment mesh that is 100% biodegradable, photodegradable, or recyclable such as burlap, twine, UV photodegradable plastic, polyester, or any other acceptable material.

Furnish biodegradable or photodegradable containment mesh when log will remain in place as part of a vegetative system.

Furnish recyclable containment mesh for temporary installations.

2.10.3. **Size**. Furnish biodegradable erosion control logs with diameters shown on the plans or as directed. Stuff containment mesh densely so logs do not deform.

3. QUALIFICATIONS, TRAINING, AND EMPLOYEE REQUIREMENTS

3.1. **Contractor Responsible Person Environmental (CRPE) Qualifications and Responsibilities**. Provide and designate in writing at the preconstruction conference a CRPE and alternate CRPE who have overall responsibility for the storm water management program. The CRPE will implement storm water and erosion control practices; will oversee and observe storm water control measure monitoring and management; will monitor the project site daily and produce daily monitoring reports as long as there are BMPs in place or soil disturbing activities are evident to ensure compliance with the SWP3 and TPDES General Permit TXR150000. During time suspensions when work is not occurring or on contract non-work days, daily inspections are not required unless a rain event has occurred. The CRPE will provide recommendations on how to improve the effectiveness of control measures. Attend the Department's preconstruction conference

for the project. Ensure training is completed as identified in Section 506.3.3., "Training," by all applicable personnel before employees work on the project. Document and submit a list, signed by the CRPE, of all applicable Contractor and subcontractor employees who have completed the training. Include the employee's name, the training course name, and date the employee completed the training. Provide the most current list at the preconstruction conference or before SWP3 or soil disturbing activities. Update the list as needed and provide the updated list when updated.

3.2. **Contractor Superintendent Qualifications and Responsibilities**. Provide a superintendent that is competent, has experience with and knowledge of storm water management, and is knowledgeable of the requirements and the conditions of the TPDES General Permit TXR150000. The superintendent will manage and oversee the day to day operations and activities at the project site; work with the CRPE to provide effective storm water management at the project site; represent and act on behalf of the Contractor; and attend the Department's preconstruction conference for the project.

3.3. **Training**. All Contractor and subcontractor employees involved in soil disturbing activities, small or large structures, storm water control measures, and seeding activities must complete training as prescribed by the Department.

4. CONSTRUCTION

4.1. **Contractor Responsibilities**. Implement the SWP3 for the project site in accordance with the plans and specifications, TPDES General Permit TXR150000, and as directed. Coordinate storm water management with all other work on the project. Develop and implement an SWP3 for project-specific material supply plants within and outside of the Department's right of way in accordance with the specific or general storm water permit requirements. Prevent water pollution from storm water associated with construction activity from entering any surface water or private property on or adjacent to the project site.

4.2. **Implementation**. The CRPE, or alternate CRPE, must be accessible by phone and able to respond to project-related storm water management or other environmental emergencies 24 hr. per day.

4.2.1. **Commencement**. Implement the SWP3 as shown and as directed. Contractor-proposed recommendations for changes will be allowed as approved. Conform to the established guidelines in the TPDES General Permit TXR150000 to make changes. Do not implement changes until approval has been received and changes have been incorporated into the plans. Minor adjustments to meet field conditions are allowed and will be recorded in the SWP3.

4.2.2. **Phasing**. Implement control measures before the commencement of activities that result in soil disturbance. Phase and minimize the soil disturbance to the areas shown on the plans. Coordinate temporary control measures with permanent control measures and all other work activities on the project to assure economical, effective, safe, and continuous water pollution prevention. Provide control measures that are appropriate to the construction means, methods, and sequencing allowed by the Contract. Exercise precaution throughout the life of the project to prevent pollution of ground waters and surface waters. Schedule and perform clearing and grubbing operations so that stabilization measures will follow immediately thereafter if project conditions permit. Bring all grading sections to final grade as soon as possible and implement temporary and permanent control measures at the earliest time possible. Implement temporary control measures when required by the TPDES General Permit TXR150000 or otherwise necessitated by project conditions.

Do not prolong final grading and shaping. Preserve vegetation where possible throughout the project, and minimize clearing, grubbing, and excavation within stream banks, bed, and approach sections.

4.3. **General**.

4.3.1. **Temporary Alterations or Control Measure Removal**. Altering or removal of control measures is allowed when control measures are restored within the same working day.

4.3.2. **Stabilization**. Initiate stabilization for disturbed areas no more than 14 days after the construction activities in that portion of the site have temporarily or permanently ceased. Establish a uniform vegetative cover or use another stabilization practice in accordance with the TPDES General Permit TXR150000.

4.3.3. **Finished Work**. Remove and dispose of all temporary control measures upon acceptance of vegetative cover or other stabilization practice unless otherwise directed. Complete soil disturbing activities and establish a uniform perennial vegetative cover. A project will not be considered for acceptance until a vegetative cover of 70% density of existing adjacent undisturbed areas is obtained or equivalent permanent stabilization is obtained in accordance with the TPDES General Permit TXR150000. An exception will be allowed in arid areas as defined in the TPDES General Permit TXR150000.

4.3.4. **Restricted Activities and Required Precautions**. Do not discharge onto the ground or surface waters any pollutants such as chemicals, raw sewage, fuels, lubricants, coolants, hydraulic fluids, bitumens, or any other petroleum product. Operate and maintain equipment on-site to prevent actual or potential water pollution. Manage, control, and dispose of litter on-site such that no adverse impacts to water quality occur. Prevent dust from creating a potential or actual unsafe condition, public nuisance, or condition endangering the value, utility, or appearance of any property. Wash out concrete trucks only as described in the TPDES General Permit TXR150000. Use appropriate controls to minimize the offsite transport of suspended sediments and other pollutants if it is necessary to pump or channel standing water (i.e., dewatering). Prevent discharges that would contribute to a violation of Edwards Aquifer Rules, water quality standards, the impairment of a listed water body, or other state or federal law.

4.4. **Installation, Maintenance, and Removal Work**. Perform work in accordance with the SWP3, according to manufacturers' guidelines, and in accordance with the TPDES General Permit TXR150000. Install and maintain the integrity of temporary erosion and sedimentation control devices to accumulate silt and debris until soil disturbing activities are completed and permanent erosion control features are in place or the disturbed area has been adequately stabilized as approved.

The Department will inspect and document the condition of the control measures at the frequency shown on the plans and will provide the Construction SWP3 Field Inspection and Maintenance Reports to the Contractor. Make corrections as soon as possible before the next anticipated rain event or within 7 calendar days after being able to enter the worksite for each control measure. The only acceptable reason for not accomplishing the corrections with the time frame specified is when site conditions are "Too Wet to Work." Take immediate action if a correction is deemed critical as directed. When corrections are not made within the established time frame, all work will cease on the project and time charges will continue while the control measures are brought into compliance. Commence work once the Engineer reviews and documents the project is in compliance. Commencing work does not release the Contractor of the liability for noncompliance of the SWP3, plans, or TPDES General Permit TXR150000.

The Engineer may limit the disturbed area if the Contractor cannot control soil erosion and sedimentation resulting from the Contractor's operations. Implement additional controls as directed.

Remove devices upon approval or as directed. Finish-grade and dress the area upon removal. Stabilize disturbed areas in accordance with the permit, and as shown on the plans or directed. Materials removed are considered consumed by the project. Retain ownership of stockpiled material and remove it from the project when new installations or replacements are no longer required.

4.4.1. **Rock Filter Dams for Erosion Control**. Remove trees, brush, stumps, and other objectionable material that may interfere with the construction of rock filter dams. Place sandbags as a foundation when required or at the Contractor's option.

Place the aggregate to the lines, height, and slopes specified, without undue voids for Types 1, 2, 3, and 5. Place the aggregate on the mesh and then fold the mesh at the upstream side over the aggregate and secure it to itself on the downstream side with wire ties, or hog rings for Types 2 and 3, or as directed. Place rock filter dams perpendicular to the flow of the stream or channel unless otherwise directed. Construct filter dams according to the following criteria unless otherwise shown on the plans:

4.4.1.1. **Type 1 (Non-Reinforced)**.

- **Height**. At least 18 in. measured vertically from existing ground to top of filter dam.
- **Top Width**. At least 2 ft.
- **Slopes**. No steeper than 2:1.

4.4.1.2. **Type 2 (Reinforced)**.

- **Height**. At least 18 in. measured vertically from existing ground to top of filter dam.
- **Top Width**. At least 2 ft.
- **Slopes**. No steeper than 2:1.

4.4.1.3. **Type 3 (Reinforced)**.

- **Height**. At least 36 in. measured vertically from existing ground to top of filter dam.
- **Top Width**. At least 2 ft.
- **Slopes**. No steeper than 2:1.

4.4.1.4. **Type 4 (Sack Gabions)**. Unfold sack gabions and smooth out kinks and bends. Connect the sides by lacing in a single loop–double loop pattern on 4- to 5-in. spacing for vertical filling. Pull the end lacing rod at one end until tight, wrap around the end, and twist 4 times. Fill with stone at the filling end, pull the rod tight, cut the wire with approximately 6 in. remaining, and twist wires 4 times.

Place the sack flat in a filling trough, fill with stone, connect sides, and secure ends as described above for horizontal filling.

Lift and place without damaging the gabion. Shape sack gabions to existing contours.

4.4.1.5. **Type 5**. Provide rock filter dams as shown on the plans.

4.4.2. **Temporary Pipe Slope Drains**. Install pipe with a slope as shown on the plans or as directed. Construct embankment for the drainage system in 8-in. lifts to the required elevations. Hand-tamp the soil around and under the entrance section to the top of the embankment as shown on the plans or as directed. Form the top of the embankment or earth dike over the pipe slope drain at least 1 ft. higher than the top of the inlet pipe at all points. Secure the pipe with hold-downs or hold-down grommets spaced a maximum of 10 ft. on center. Construct the energy dissipaters or sediment traps as shown on the plans or as directed. Construct the sediment trap using concrete or rubble riprap in accordance with Item 432, “Riprap,” when designated on the plans.

4.4.3. **Temporary Paved Flumes**. Construct paved flumes as shown on the plans or as directed. Provide excavation and embankment (including compaction of the subgrade) of material to the dimensions shown on the plans unless otherwise indicated. Install a rock or rubble riprap energy dissipater, constructed from the materials specified above, to a minimum depth of 9 in. at the flume outlet to the limits shown on the plans or as directed.

4.4.4. **Construction Exits**. Prevent traffic from crossing or exiting the construction site or moving directly onto a public roadway, alley, sidewalk, parking area, or other right of way areas other than at the location of construction exits when tracking conditions exist. Construct exits for either long- or short-term use.

4.4.4.1. **Long-Term**. Place the exit over a foundation course as required. Grade the foundation course or compacted subgrade to direct runoff from the construction exits to a sediment trap as shown on the plans or as directed. Construct exits with a width of at least 14 ft. for one-way and 20 ft. for two-way traffic for the full width of the exit, or as directed.

4.4.4.1.1. **Type 1**. Construct to a depth of at least 8 in. using crushed aggregate as shown on the plans or as directed.

4.4.4.1.2. **Type 2**. Construct using railroad ties and timbers as shown on the plans or as directed.

4.4.4.2. **Short-Term**.

4.4.4.2.1. **Type 3**. Construct using crushed aggregate, plywood, or wafer board. This type of exit may be used for daily operations where long-term exits are not practical.

4.4.4.2.2. **Type 4**. Construct as shown on the plans or as directed.

4.4.5. **Earthwork for Erosion Control**. Perform excavation and embankment operations to minimize erosion and to remove collected sediments from other erosion control devices.

4.4.5.1. **Excavation and Embankment for Erosion Control Features**. Place earth dikes, swales, or combinations of both along the low crown of daily lift placement, or as directed, to prevent runoff spillover. Place swales and dikes at other locations as shown on the plans or as directed to prevent runoff spillover or to divert runoff. Construct cuts with the low end blocked with undisturbed earth to prevent erosion of hillsides. Construct sediment traps at drainage structures in conjunction with other erosion control measures as shown on the plans or as directed.

Create a sediment basin, where required, providing 3,600 cu. ft. of storage per acre drained, or equivalent control measures for drainage locations that serve an area with 10 or more disturbed acres at one time, not including offsite areas.

4.4.5.2. **Excavation of Sediment and Debris**. Remove sediment and debris when accumulation affects the performance of the devices, after a rain, and when directed.

4.4.6. **Construction Perimeter Fence**. Construct, align, and locate fencing as shown on the plans or as directed.

4.4.6.1. **Installation of Posts**. Embed posts 18 in. deep or adequately anchor in rock, with a spacing of 8 to 10 ft.

4.4.6.2. **Wire Attachment**. Attach the top wire to the posts at least 3 ft. from the ground. Attach the lower wire midway between the ground and the top wire.

4.4.6.3. **Flag Attachment**. Attach flagging to both wire strands midway between each post. Use flagging at least 18 in. long. Tie flagging to the wire using a square knot.

4.4.7. **Sandbags for Erosion Control**. Construct a berm or dam of sandbags that will intercept sediment-laden storm water runoff from disturbed areas, create a retention pond, detain sediment, and release water in sheet flow. Fill each bag with sand so that at least the top 6 in. of the bag is unfilled to allow for proper tying of the open end. Place the sandbags with their tied ends in the same direction. Offset subsequent rows of sandbags 1/2 the length of the preceding row. Place a single layer of sandbags downstream as a secondary debris trap. Place additional sandbags as necessary or as directed for supplementary support to berms or dams of sandbags or earth.

4.4.8. **Temporary Sediment-Control Fence**. Provide temporary sediment-control fence near the downstream perimeter of a disturbed area to intercept sediment from sheet flow. Incorporate the fence into erosion-control measures used to control sediment in areas of higher flow. Install the fence as shown on the plans, as specified in this Section, or as directed.

4.4.8.1. **Installation of Posts**. Embed posts at least 18 in. deep, or adequately anchor, if in rock, with a spacing of 6 to 8 ft. and install on a slight angle toward the runoff source.

4.4.8.2. **Fabric Anchoring**. Dig trenches along the uphill side of the fence to anchor 6 to 8 in. of fabric. Provide a minimum trench cross-section of 6 × 6 in. Place the fabric against the side of the trench and align approximately 2 in. of fabric along the bottom in the upstream direction. Backfill the trench, then hand-tamp.

4.4.8.3. **Fabric and Net Reinforcement Attachment**. Attach the reinforcement to wooden posts with staples, or to steel posts with T-clips, in at least 4 places equally spaced unless otherwise shown on the plans. Sewn

vertical pockets may be used to attach reinforcement to end posts. Fasten the fabric to the top strand of reinforcement by hog rings or cord every 15 in. or less.

4.4.8.4. **Fabric and Net Splices**. Locate splices at a fence post with a minimum lap of 6 in. attached in at least 6 places equally spaced unless otherwise shown on the plans. Do not locate splices in concentrated flow areas.

Requirements for installation of used temporary sediment-control fence include the following:

- fabric with minimal or no visible signs of biodegradation (weak fibers),
- fabric without excessive patching (more than 1 patch every 15 to 20 ft.),
- posts without bends, and
- backing without holes.

4.4.9. **Biodegradable Erosion Control Logs**. Install biodegradable erosion control logs near the downstream perimeter of a disturbed area to intercept sediment from sheet flow. Incorporate the biodegradable erosion control logs into the erosion measures used to control sediment in areas of higher flow. Install, align, and locate the biodegradable erosion control logs as specified below, as shown on the plans, or as directed.

Secure biodegradable erosion control logs in a method adequate to prevent displacement as a result of normal rain events, prevent damage to the logs, and as approved, such that flow is not allowed under the logs. Temporarily removing and replacing biodegradable erosion logs as to facilitate daily work is allowed at the Contractor's expense.

4.4.10. **Vertical Tracking**. Perform vertical tracking on slopes to temporarily stabilize soil. Provide equipment with a track undercarriage capable of producing a linear soil impression measuring a minimum of 12 in. long × 2 to 4 in. wide × 1/2 to 2 in. deep. Do not exceed 12 in. between track impressions. Install continuous linear track impressions where the 12 in. length impressions are perpendicular to the slope. Vertical tracking is required on projects where soil disturbing activities have occurred unless otherwise approved.

4.5. **Monitoring and Documentation**. Monitor the control measures on a daily basis as long as there are BMPs in place and/or soil disturbing activities are evident to ensure compliance with the SWP3 and TPDES General Permit TXR150000. During time suspensions when work is not occurring or contract non-work days, daily inspections are not required unless a rain event has occurred. Monitoring will consist of, but is not limited to, observing, inspecting, and documenting site locations with control measures and discharge points to provide maintenance and inspection of controls as described in the SWP3. Keep written records of daily monitoring. Document in the daily monitoring report the control measure condition, the date of inspection, required corrective actions, responsible person for making the corrections, and the date corrective actions were completed. Maintain records of all monitoring reports at the project site or at an approved place. Provide copies within 7 days. Together, the CRPE and an Engineer's representative will complete the Construction Stage Gate Checklist on a periodic basis as directed.

5. MEASUREMENT

5.1. **Rock Filter Dams**. Installation or removal of rock filter dams will be measured by the foot or by the cubic yard. The measured volume will include sandbags, when used.

5.1.1. **Linear Measurement**. When rock filter dams are measured by the foot, measurement will be along the centerline of the top of the dam.

5.1.2. **Volume Measurement**. When rock filter dams are measured by the cubic yard, measurement will be based on the volume of rock computed by the method of average end areas.

5.1.2.1. **Installation**. Measurement will be made in final position.

5.1.2.2. **Removal**. Measurement will be made at the point of removal.

5.2. **Temporary Pipe Slope Drains**. Temporary pipe slope drains will be measured by the foot.

5.3. **Temporary Paved Flumes**. Temporary paved flumes will be measured by the square yard of surface area. The measured area will include the energy dissipater at the flume outlet.

5.4. **Construction Exits**. Construction exits will be measured by the square yard of surface area.

5.5. **Earthwork for Erosion and Sediment Control**.

5.5.1. **Equipment and Labor Measurement**. Equipment and labor used will be measured by the actual number of hours the equipment is operated and the labor is engaged in the work.

5.5.2. **Volume Measurement**.

5.5.2.1. **In Place**.

5.5.2.1.1. **Excavation**. Excavation will be measured by the cubic yard in its original position and the volume computed by the method of average end areas.

5.5.2.1.2. **Embankment**. Embankment will be measured by the cubic yard in its final position by the method of average end areas. The volume of embankment will be determined between:

- the original ground surfaces or the surface upon that the embankment is to be constructed for the feature and
- the lines, grades and slopes of the accepted embankment for the feature.

5.5.2.2. **In Vehicles**. Excavation and embankment quantities will be combined and paid for under "Earthwork (Erosion and Sediment Control, In Vehicle)." Excavation will be measured by the cubic yard in vehicles at the point of removal. Embankment will be measured by the cubic yard in vehicles measured at the point of delivery. Shrinkage or swelling factors will not be considered in determining the calculated quantities.

5.6. **Construction Perimeter Fence**. Construction perimeter fence will be measured by the foot.

5.7. **Sandbags for Erosion Control**. Sandbags will be measured as each sandbag or by the foot along the top of sandbag berms or dams.

5.8. **Temporary Sediment-Control Fence**. Installation or removal of temporary sediment-control fence will be measured by the foot.

5.9. **Biodegradable Erosion Control Logs**. Installation or removal of biodegradable erosion control logs will be measured by the foot along the centerline of the top of the control logs.

5.10. **Vertical Tracking**. Vertical tracking will not be measured or paid for directly but is considered subsidiary to this Item.

6. PAYMENT

The following will not be paid for directly but are subsidiary to pertinent Items:

- erosion-control measures for Contractor project-specific locations (PSLs) inside and outside the right of way (such as construction and haul roads, field offices, equipment and supply areas, plants, and material sources);
- removal of litter, unless a separate pay item is shown on the plans;
- repair to devices and features damaged by Contractor operations;
- added measures and maintenance needed due to negligence, carelessness, lack of maintenance, and failure to install permanent controls;

- removal and reinstallation of devices and features needed for the convenience of the Contractor;
- finish grading and dressing upon removal of the device; and
- minor adjustments including but not limited to plumbing posts, reattaching fabric, minor grading to maintain slopes on an erosion embankment feature, or moving small numbers of sandbags.

Stabilization of disturbed areas will be paid for under pertinent Items except vertical tacking which is subsidiary.

Furnishing and installing pipe for outfalls associated with sediment traps and ponds will not be paid for directly but is subsidiary to the excavation and embankment under this Item.

6.1. **Rock Filter Dams**. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid as follows:

6.1.1. **Installation**. Installation will be paid for as "Rock Filter Dams (Install)" of the type specified. This price is full compensation for furnishing and operating equipment, finish backfill and grading, lacing, proper disposal, labor, materials, tools, and incidentals.

6.1.2. **Removal**. Removal will be paid for as "Rock Filter Dams (Remove)." This price is full compensation for furnishing and operating equipment, proper disposal, labor, materials, tools, and incidentals.

When the Engineer directs that the rock filter dam installation or portions thereof be replaced, payment will be made at the unit price bid for "Rock Filter Dams (Remove)" and for "Rock Filter Dams (Install)" of the type specified. This price is full compensation for furnishing and operating equipment, finish backfill and grading, lacing, proper disposal, labor, materials, tools, and incidentals.

6.2. **Temporary Pipe Slope Drains**. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Temporary Pipe Slope Drains" of the size specified. This price is full compensation for furnishing materials, removal and disposal, furnishing and operating equipment, labor, tools, and incidentals.

Removal of temporary pipe slope drains will not be paid for directly but is subsidiary to the installation Item. When the Engineer directs that the pipe slope drain installation or portions thereof be replaced, payment will be made at the unit price bid for "Temporary Pipe Slope Drains" of the size specified, which is full compensation for the removal and reinstallation of the pipe drain.

Earthwork required for the pipe slope drain installation, including construction of the sediment trap, will be measured and paid for under "Earthwork for Erosion and Sediment Control."

Riprap concrete or stone, when used as an energy dissipater or as a stabilized sediment trap, will be measured and paid for in accordance with Item 432, "Riprap."

6.3. **Temporary Paved Flumes**. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Temporary Paved Flume (Install)" or "Temporary Paved Flume (Remove)." This price is full compensation for furnishing and placing materials, removal and disposal, equipment, labor, tools, and incidentals.

When the Engineer directs that the paved flume installation or portions thereof be replaced, payment will be made at the unit prices bid for "Temporary Paved Flume (Remove)" and "Temporary Paved Flume (Install)." These prices are full compensation for the removal and replacement of the paved flume and for equipment, labor, tools, and incidentals.

Earthwork required for the paved flume installation, including construction of a sediment trap, will be measured and paid for under "Earthwork for Erosion and Sediment Control."

6.4. **Construction Exits**. Contractor-required construction exits from off right of way locations or on-right of way PSLs will not be paid for directly but are subsidiary to pertinent Items.

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" for construction exits needed on right of way access to work areas required by the Department will be paid for at the unit price bid for "Construction Exits (Install)" of the type specified or "Construction Exits (Remove)." This price is full compensation for furnishing and placing materials, excavating, removal and disposal, cleaning vehicles, labor, tools, and incidentals.

When the Engineer directs that a construction exit or portion thereof be removed and replaced, payment will be made at the unit prices bid for "Construction Exit (Remove)" and "Construction Exit (Install)" of the type specified. These prices are full compensation for the removal and replacement of the construction exit and for equipment, labor, tools, and incidentals.

Construction of sediment traps used in conjunction with the construction exit will be measured and paid for under "Earthwork for Erosion and Sediment Control."

6.5. **Earthwork for Erosion and Sediment Control**.

6.5.1. **Initial Earthwork for Erosion and Sediment Control**. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Excavation (Erosion and Sediment Control, In Place)," "Embankment (Erosion and Sediment Control, In Place)," "Excavation (Erosion and Sediment Control, In Vehicle)," "Embankment (Erosion and Sediment Control, (In Vehicle)," or "Earthwork (Erosion and Sediment Control, In Vehicle)."

This price is full compensation for excavation and embankment including hauling, disposal of material not used elsewhere on the project; embankments including furnishing material from approved sources and construction of erosion-control features; and equipment, labor, tools, and incidentals.

Sprinkling and rolling required by this Item will not be paid for directly but will be subsidiary to this Item.

6.5.2. **Maintenance Earthwork for Erosion and Sediment Control for Cleaning and Restoring Control Measures**. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid under a Contractor Force Account Item from invoice provided to the Engineer.

This price is full compensation for excavation, embankment, and re-grading including removal of accumulated sediment in various erosion control installations as directed, hauling, and disposal of material not used elsewhere on the project; excavation for construction of erosion-control features; embankments including furnishing material from approved sources and construction of erosion-control features; and equipment, labor, tools, and incidentals.

Earthwork needed to remove and obliterate erosion-control features will not be paid for directly but is subsidiary to pertinent Items unless otherwise shown on the plans.

Sprinkling and rolling required by this Item will not be paid for directly but will be subsidiary to this Item.

6.6. **Construction Perimeter Fence**. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Construction Perimeter Fence." This price is full compensation for furnishing and placing the fence; digging, fence posts, wire, and flagging; removal and disposal; and materials, equipment, labor, tools, and incidentals.

Removal of construction perimeter fence will be not be paid for directly but is subsidiary to the installation Item. When the Engineer directs that the perimeter fence installation or portions thereof be removed and replaced, payment will be made at the unit price bid for "Construction Perimeter Fence," which is full compensation for the removal and reinstallation of the construction perimeter fence.

6.7. **Sandbags for Erosion Control**. Sandbags will be paid for at the unit price bid for "Sandbags for Erosion Control" (of the height specified when measurement is by the foot). This price is full compensation for materials, placing sandbags, removal and disposal, equipment, labor, tools, and incidentals.

Removal of sandbags will not be paid for directly but is subsidiary to the installation Item. When the Engineer directs that the sandbag installation or portions thereof be replaced, payment will be made at the unit price bid for "Sandbags for Erosion Control," which is full compensation for the reinstallation of the sandbags.

6.8. **Temporary Sediment-Control Fence**. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid as follows:

6.8.1. **Installation**. Installation will be paid for as "Temporary Sediment-Control Fence (Install)." This price is full compensation for furnishing and operating equipment finish backfill and grading, lacing, proper disposal, labor, materials, tools, and incidentals.

6.8.2. **Removal**. Removal will be paid for as "Temporary Sediment-Control Fence (Remove)." This price is full compensation for furnishing and operating equipment, proper disposal, labor, materials, tools, and incidentals.

6.9. **Biodegradable Erosion Control Logs**. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid as follows:

6.9.1. **Installation**. Installation will be paid for as "Biodegradable Erosion Control Logs (Install)" of the size specified. This price is full compensation for furnishing and operating equipment finish backfill and grading, staking, proper disposal, labor, materials, tools, and incidentals.

6.9.2. **Removal**. Removal will be paid for as "Biodegradable Erosion Control Logs (Remove)." This price is full compensation for furnishing and operating equipment, proper disposal, labor, materials, tools, and incidentals.

6.10. **Vertical Tracking**. Vertical tracking will not be measured or paid for directly but is considered subsidiary to this Item.

Item 510
One-Way Traffic Control

1. DESCRIPTION

Provide one-way traffic control using one of the methods shown on the plans.

2. WORK METHODS

2.1. **Flagger Control Method**. Furnish flaggers in accordance with the requirements of Article 7.2., "Safety," at all entry points to the work zone, to stop traffic. Furnish a Stop/Slow paddle that meets the requirements of the TMUTCD for each flagger. If desired, use Automated Flagger Assistance Devices if approved.

2.2. **Pilot Car Method**. Furnish a licensed driver and pilot vehicle with required signs attached. Furnish flaggers on each approach to the activity area to control traffic. Provide Stop/Slow paddles and signs that meet the requirements of the TMUTCD. Instruct drivers to follow the pilot vehicle and to not pass the cars ahead.

2.3. **Portable Traffic Signal Method**. Furnish, operate, and maintain new or used portable traffic signal units. Assure used units are in good working condition and are approved before use. A list of approved units can be found in the Department's *Compliant Work Zone Traffic Control Device List*. Units will remain the property of the Contractor.

3. MEASUREMENT

When shown on the plans as a bid item, this Item will be measured as follows:

3.1. **Flagger Control Method**. By the actual number of hours flaggers are engaged in flagging activities. Each flagger will be measured separately.

3.2. **Pilot Car Method**. By the actual number of hours of use for the combination of flaggers and pilot vehicle.

3.3. **Portable Traffic Signal Method**. By the month, including 2 units operated by a single controller set up and operational on the worksite.

4. PAYMENT

Unless otherwise shown on the plans, the work performed and materials furnished in accordance with this Item will not be paid for directly but will be subsidiary to pertinent Items.

When shown on the plans as a bid item, the work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for the method specified. This price is full compensation for furnishing and operating equipment, pilot car, pilot vehicle driver, flaggers, signs, labor, tools, and incidentals. Payment for Portable Traffic Signal units and Portable Traffic Signals will be full compensation for the units, set up, relocating, removing, replacing parts, batteries, fuel, oil, and incidentals.

Item 540
Metal Beam Guard Fence

1. DESCRIPTION

Furnish, install, replace, or adjust metal beam guard fence consisting of metal beam rail elements, hardware, blocks, and support posts.

2. MATERIALS

Provide samples of metal beam rail elements, terminal sections, bolts, and nuts for compliance testing according to Tex-708-I and Tex-713-I to verify physical and chemical properties meet AASHTO M 180 when directed.

Obtain materials at the locations shown on the plans when the plans designate that the Department will furnish materials.

2.1. **Metal Beam Rail Elements**. Furnish new metal beam rail elements, transitions, anchor sections, and terminals that meet the requirements of Table 1 and are from a manufacturer on the Department's MPL of rail element manufacturers.

Type I or II is required, unless otherwise shown on the plans. Base metal for metal beam rail elements must not contain more than 0.04% phosphorous or more than 0.05% sulfur.

Warped or deformed rail elements will be rejected.

Table 1
Rail Element Requirements

Specification	AASHTO M 180
Class	A— Base metal nominal thickness 0.105 in. B— Base metal nominal thickness 0.135 in.
Type	I— Zinc-coated 1.80 oz. per square foot minimum single-spot. II— Zinc-coated 3.60 oz. per square foot minimum single-spot. IV— Weathering Steel (required when shown on the plans).
Shape	W-Beam Thrie Beam W-Beam to Thrie Beam Transition
Markings	Permanently mark each metal beam rail element with the information required in AASHTO M 180. In addition, permanently mark all curved sections of metal beam rail element with the radius of the curved section in the format "R=XX ft." Markings must be on the back of the metal beam rail section away from traffic and visible after erection.

2.2. **Posts**. Furnish new round timber, rectangular timber, or rolled steel section posts in accordance with details shown on the plans and the following requirements:

2.2.1. **Timber Posts**. Meet the requirements of DMS-7200, "Timber Posts and Blocks for Metal Beam Guard Fence." Purchase from a manufacturer or supplier on the Department's MPL of timber treating plants and suppliers.

2.2.2. **Steel Posts**. Provide rolled sections conforming to the material requirements of ASTM A36. Drill or punch posts for standard rail attachment as shown on the plans. Galvanize according to Item 445, "Galvanizing." Low-fill culvert posts may be fabricated as galvanized "blanks" with the rail hole and the final height field fabricated. Treat all exposed post surfaces caused by the field fabrication in accordance with Section 445.3.5., "Repairs."

2.3. **Blocks**. Furnish new rectangular timber or composite blocks in accordance with details shown on the plans and the following requirements:

2.3.1. **Timber**. Meet the requirements of DMS-7200, "Timber Posts and Blocks for Metal Beam Guard Fence." Purchase from a manufacturer or supplier on the Department's MPL of timber treating plants and suppliers.

2.3.2. **Composite**. Meet the requirements of DMS-7210, "Composite Material Posts and Blocks for Metal Beam Guard Fence." Purchase from a manufacturer on the Department's MPL of composite material blocks and posts.

2.4. **Fittings**. Furnish new fittings (bolts, nuts, and washers) according to the details shown on the plans and galvanized according to Item 445, "Galvanizing."

2.5. **Terminal Connectors**. Furnish new terminal connectors, where required, meeting the material and galvanizing requirements specified for metal beam rail elements.

2.6. **Concrete**. Furnish concrete for terminal anchor posts meeting the requirements for Class A concrete as required in Item 421, "Hydraulic Cement Concrete."

2.7. **Curb**. If indicated in the details, furnish the curb shown with metal beam guard fence transition as required by Item 529, "Concrete Curb, Gutter, and Combined Curb and Gutter."

2.8. **Terminal Anchor Posts**. Furnish new terminal anchor posts from steel conforming to the material requirements of ASTM A36. Fabricate posts according to Item 441, "Steel Structures." Galvanize terminal anchor posts after fabrication according to Item 445, "Galvanizing."

2.9. **Driveway Terminal Anchor Posts**. Furnish new terminal anchor posts from steel conforming to the material requirements of ASTM A36. Fabricate posts according to Item 441, "Steel Structures." Galvanize terminal anchor posts after fabrication according to Item 445, "Galvanizing."

2.10. **Downstream Anchor Posts**. Furnish new terminal anchor posts consisting of new rectangular timber and new steel foundation tubes according to details shown on the plans.

2.11. **Downstream Anchor Hardware**. Furnish new hardware (brackets, plates, struts, cable, etc.) according to the details shown on the plans and galvanized according to Item 445, "Galvanizing."

2.12. **Controlled Released Terminal (CRT) Posts**. Furnish new CRT posts according to the details shown on the plans and conforming to the requirements of DMS-7200, "Timber Posts and Blocks for Metal Beam Guard Fence." Purchase from a manufacturer or supplier on the Department's MPL of timber treating plants and suppliers.

3. CONSTRUCTION

Install posts and rail elements according to details shown on the plans.

3.1. **Posts**. Install posts by either drilling or driving.

3.1.1. **Drilling**. Drill holes and set posts plumb and firm to the line and grade shown. Backfill posts by thoroughly compacting material to the density of adjacent undisturbed material.

3.1.2. **Driving**. Drive posts plumb with approved power hammers (steam, compressed air, vibratory, or diesel) or gravity hammers to the line and grade shown while preventing damage to the post. Use pilot holes when required and approved. Determine the size and depth of pilot holes based on results of the first few posts driven. Thoroughly tamp loosened soil around the post, fill voids with suitable material, and thoroughly compact to the density of adjacent undisturbed material.

3.2. **Rail Elements**. Erect metal beam rail elements to produce a smooth, continuous rail paralleling the line and grade of the roadway surface or as shown on the plans. Bolt rail elements end-to-end and lap splices in the direction of traffic. Field-drill or punch holes in rail elements for special details, only when approved.

3.3. **Short Radius**. Special rail fabrication with a required radius must be as shown on the plans.

3.4. **Terminal Anchor Posts**. Embed terminal anchor posts in concrete, unless otherwise shown on the plans.

3.5. **Galvanizing Repair**. Repair all parts of galvanized steel posts, washers, bolts, and rail elements after erection where galvanizing has become scratched, chipped, or otherwise damaged. Repair in accordance with Section 445.3.5., "Repairs."

3.6. **Guardrail Adjustment**. Work includes vertical adjustment, horizontal shift, and overlap of the rail element to meet the detail shown on the plans.

3.7. **Curb**. If indicated in the details, construct the curb shown with metal beam guard fence transition as required by Item 529, "Concrete Curb, Gutter, and Combined Curb and Gutter."

3.8. **Driveway Terminal Anchor Posts**. Embed terminal anchor posts in concrete, unless otherwise shown on the plans.

4. MEASUREMENT

4.1. **Guard Fence**. Measurement will be by the foot of fence. Fence will be measured on the face of the rail in place, from center-to-center of end splice locations.

4.2. **Terminal Anchor Sections**. Measurement will be by each section, complete in place, consisting of a terminal anchor post and one 25-ft. section of rail element.

4.3. **Transitions**. Transitions for rail connection will be measured by each transition.

4.4. **Short Radius**. Measurement will be by the foot to the nearest whole foot along the face of the rail in place, from beginning of radius (first CRT post) to the end of radius.

4.5. **Driveway Terminal Anchor Section**. Measurement will be by each section, complete in place, consisting of a driveway terminal anchor post and one 6-ft. section of rail element.

4.6. **Downstream Anchor Terminal**. Measurement will be by each section, complete in place, consisting of one W-Beam end section, 2 downstream anchor posts, and one rail section.

4.7. **Long Span System**. Measurement will be by the foot of fence. Fence will be measured on the face of the rail, in place, between the first CRT and last CRT posts in the system.

5. PAYMENT

The work performed and material furnished in accordance with this Item and measured as provided under "Measurement" will be paid at the unit price bid for "Metal W-Beam Guard Fence" of the post type specified; "Metal Thrie Beam Guard Fence" of the post type specified; "Terminal Anchor Section"; "Metal Beam Guard Fence Transition" of the type specified; "Metal W-Beam Guard Fence Adjustment"; "Metal Thrie Beam Guard Fence Adjustment"; "Terminal Anchor Section Adjustment"; "Transition Adjustment"; "Short Radius"; "Driveway Terminal Anchor Section; "Downstream Anchor Terminal"; or "Metal Beam Guard Fence (Long Span System)." When weathering steel is required, Type IV will be specified.

Samples furnished to the Department for testing purposes, special backfill materials, and concrete curbs will not be paid directly but are subsidiary to this Item.

5.1. **Guard Fence**. The price bid for "Metal W-Beam Guard Fence" or "Metal Thrie Beam Guard Fence" is full compensation for materials, hauling, erection, setting posts in concrete, blocks, driving posts, excavating, backfilling, equipment, labor, tools, and incidentals.

5.2. **Terminal Anchor Section**. When a separate bid item is specified, the price bid for "Terminal Anchor Section" is full compensation for furnishing the rail element, anchor assembly, terminal anchor post, and foundations; installing the rail element anchor assembly and the terminal anchor post and foundations; excavation and backfilling; and equipment, labor, tools, and incidentals.

5.3. **Transition**. The price bid for "Metal Beam Guard Fence Transition" is full compensation for furnishing nested sections of Thrie Beam; nested sections of W-Beam; Thrie Beam to W-Beam transitional rail piece, posts, concrete, curb, and connections to W-Beam guard fence and bridge rails; Thrie Beam terminal connectors; excavation and backfilling; and equipment, labor, tools, and incidentals.

5.4. **Guardrail Adjustment**. The price bid for "Metal W-Beam Guard Fence Adjustment," "Metal Thrie Beam Guard Fence Adjustment," "Terminal Anchor Section Adjustment," and "Transition Adjustment" is full compensation for furnishing materials not supplied by the Department, drilling holes in posts, hauling, erection, blocks, excavation, backfill, cleaning, salvaging materials, setting rail element anchor assembly and terminal anchor post, removal of rail element, concrete, curb, equipment, labor, tools, and incidentals.

5.5. **Short Radius**. The price bid for "Short Radius" is full compensation for furnishing special rail fabricated metal beam guard fence, CRT posts, steel posts, sand barrels, end terminal, cable anchor, materials, hauling, erection, blocks, driving posts, excavating, backfilling, equipment, labor, tools, and incidentals.

5.6. **Driveway Terminal Anchor Section**. The price bid for "Driveway Terminal Anchor Section" is full compensation for furnishing the rail element, driveway anchor assembly, driveway terminal anchor post, and foundations; installing the rail element anchor assembly and the driveway terminal anchor post and foundations; excavation and backfilling; and equipment, labor, tools, and incidentals.

5.7. **Downstream Anchor Terminal**. The price bid for "Downstream Anchor Terminal" is full compensation for furnishing the rail element, W-Beam end section, guardrail anchor bracket, shelf angle bracket, channel strut, downstream anchor posts, breakaway cable terminal (BCT) cable anchor assembly, and foundations; installing the BCT cable anchor assembly and the downstream anchor post and foundations; excavation and backfilling; and equipment, labor, tools, and incidentals.

5.8. **Long Span System**. The price bid for "Metal Beam Guard Fence (Long Span System)" is full compensation for furnishing the rail element, CRT posts, materials, hauling, erection, blocks, driving posts, excavating, backfilling, equipment, labor, tools, and incidentals.

Item 544
Guardrail End Treatments

1. DESCRIPTION

Furnish and install, move, or remove guardrail end treatments.

2. MATERIALS

Furnish new materials from the Department's MPL of rail element manufacturers. Obtain materials at the location shown on the plans when furnished by the Department.

3. CONSTRUCTION

Install guardrail end treatments in accordance with manufacturer's assembly and installation requirements and the details shown on the plans. Provide the Engineer with manufacturer's installation and repair manuals specific to the guardrail end treatment.

Move or remove guardrail end treatments in accordance with the plans and as directed. Deliver salvageable materials in accordance with the plans or as directed. Dispose of unsalvageable materials in accordance with federal, state, and local regulations.

4. MEASUREMENT

This Item will be measured by each guardrail end treatment.

5. PAYMENT

The work performed and the materials furnished in accordance with this Item and measured as provided for under "Measurement" will be paid for at the unit price bid for "Guardrail End Treatment (Install)" of the post and type specified where applicable, "Guardrail End Treatment (Move and Reset)," or "Guardrail End Treatment (Remove)." This price is full compensation for foundations, materials, stockpiling, disposal of unsalvageable materials, equipment, labor, tools, and incidentals.

Payment for "Guardrail End Treatment (Move and Reset)" will include each guardrail end treatment removed from a stockpile or from an existing location and reset in a new location as detailed on the plans or as directed.

Payment for "Guardrail End Treatment (Remove)" will include each guardrail end treatment removed from an existing location and stockpiled at the location designated on the plans, disposed, or as otherwise directed.

Item 560
Mailbox Assemblies

1. DESCRIPTION

Install, remove, temporarily relocate, or replace mailbox assemblies of the type specified.

2. MATERIAL

Furnish mailbox assemblies in accordance with the plans. An assembly does not include the mailbox unless shown otherwise on the plans. Provide new mailbox assemblies for permanent installations.

3. CONSTRUCTION

Temporarily relocate mailbox assemblies as shown on the plans or as directed. Furnish and install approved mailbox assemblies and mount mailboxes on those assemblies. Maintain mailbox assemblies in a serviceable condition. Furnish and install additional mailbox assemblies as directed. Relocate mailbox and assemblies to permanent locations upon completion of construction work.

4. MEASUREMENT

This Item will be measured by each permanent mailbox assembly installed.

5. PAYMENT

The work performed, materials furnished, and measured according to “Measurement” will be paid at the unit price bid for “Mailbox Installation (Single),” of the type specified; “Mailbox Installation (Double),” of the type specified; or “Mailbox Installation (Multiple),” of the type specified. This price is full compensation for installing mailboxes and reflectors in permanent locations, materials, equipment, labor, tools, and incidentals. Removing existing or installing and moving temporary mailbox assemblies will not be paid directly but will be subsidiary to pertinent Items.

Item 585
Ride Quality for Pavement Surfaces

1. DESCRIPTION

Measure and evaluate the ride quality of pavement surfaces.

2. EQUIPMENT

2.1. **Surface Test Type A**. Provide a 10-ft. straightedge or where allowed, a high-speed or lightweight inertial profiler, certified at the Texas A&M Transportation Institute.

2.2. **Surface Test Type B**. Provide a high-speed or lightweight inertial profiler, certified at the Texas A&M Transportation Institute. Provide equipment certification documentation. Display a current decal on the equipment indicating the certification expiration date.

Use a certified profiler operator from the Department's MPL. When requested, furnish documentation for the person certified to operate the profiler.

2.3. **Diamond Grinding Equipment**. Provide self-propelled powered grinding equipment specifically designed to smooth and texture pavements using circular diamond blades when grinding is required. Provide equipment with automatic grade control capable of grinding at least 3 ft. of width longitudinally in each pass without damaging the pavement.

3. WORK METHODS

Measure and evaluate profiles using Surface Test Types A and B on surfaces as described below unless otherwise shown on the plans.

3.1. **Transverse Profile**. Measure the transverse profile of the finished riding surface in accordance with Surface Test Type A.

3.2. **Longitudinal Profile**. Measure the longitudinal profile of the surface, including horizontal curves.

3.2.1. **Travel Lanes**. Unless otherwise shown on the plans, use Surface Test Type B on the final riding surface of all travel lanes except as follows:

3.2.1.1. **Service Roads and Ramps**. Use Surface Test Type A on service roads and ramps unless Surface Test Type B is shown on the plans.

3.2.1.2. **Short Projects**. Use Surface Test Type A when project pavement length is less than 2,500 ft. unless otherwise shown on the plans.

3.2.1.3. **Bridge Structures**. Measure the profile in accordance with the pertinent item or use Surface Test Type A for span type bridge structures, approach slabs, and the 100 ft. leading into and away from such structures.

3.2.1.4. **Leave-Out Sections**. Use Surface Test Type A for leave-out sections and areas between leave-out sections that are less than 100 ft.

3.2.1.5. **Ends**. Use Surface Test Type A on the first and last 100 ft. of the project pavement length.

3.2.2. **Shoulders and Other Areas**. Use Surface Test Type A for shoulders and all other areas including intermediate pavement layers.

3.3. **Profile Measurements**. Measure the finished surface in accordance with Surface Test Type A or B in accordance with Section 585.3.1., "Transverse Profile," Section 585.3.2., "Longitudinal Profile," and the plans.

3.3.1. **Surface Test Type A**. Test the surface with a 10-ft. straightedge as directed. Use an inertial profiler to measure the surface when allowed. The Engineer will use Department software to evaluate the surface.

3.3.2. **Surface Test Type B**.

3.3.2.1. **QC Testing**. Perform QC tests on a daily basis throughout the duration of the project. Use a 10-ft. straightedge, inertial profiler, profilograph, or any other means to perform QC tests.

3.3.2.2. **QA Testing**. Perform QA tests using either a high-speed or lightweight inertial profiler. Coordinate with and obtain authorization from the Engineer before starting QA testing. Perform QA tests on the finished surface of the completed project or at the completion of a major stage of construction, as approved. Perform QA tests within 7 days after receiving authorization.

The Engineer may require QA testing to be performed at times of off-peak traffic flow. Operate the inertial profiler in a manner that does not unduly disrupt traffic flow as directed. When using a lightweight inertial profiler to measure a surface that is open to traffic, use a moving traffic control plan in accordance with Part 6 of the TMUTCD and the plans.

In accordance with Tex-1001-S, operate the inertial profiler and deliver test results within 24 hr. of testing. Provide all profile measurements in electronic data files using the format specified in Tex-1001-S.

3.3.2.2.1. **Verification Testing**. The Engineer may perform ride quality verification testing within 10 working days after the Contractor's QA testing is complete for the project or major stage of construction. When the Department's profiler produces an overall average international roughness index (IRI) value over 3.0 in. per mile higher than the value calculated using Contractor data, the Engineer will decide whether to accept the Contractor's data, use the Department's data, use an average of both parties' data, or request a referee test. Referee testing is mandatory if the difference is greater than 6.0 in. per mile.

3.3.2.2.2. **Referee Testing**. The Construction Division will conduct referee testing, and the results are final. The Construction Division may require recertification for the Contractor's or Department's inertial profiler.

3.4. **Acceptance Plan and Payment Adjustments**. The Engineer will evaluate profiles for determining acceptance, payment adjustment, and corrective action.

3.4.1. **Surface Test Type A**. Use diamond grinding or other approved work methods to correct surface areas that have more than 1/8-in. variation between any 2 contacts on a 10-ft. straightedge. For asphalt concrete pavements, fog seal the aggregate exposed from diamond grinding. Following corrective action, retest the area to verify compliance with this Item.

3.4.2. **Surface Test Type B**. The Engineer will use the QA test results to determine payment adjustments for ride quality using Department software. IRI values will be calculated using the average of both wheel paths. When taking corrective actions to improve a deficient 0.1-mi. section, payment adjustments will be based on the data obtained from reprofiling the corrected area.

3.4.2.1. **IRI Payment Adjustment for 0.1-mi. Sections**. Unless payment adjustment Schedule 1 or 2 is shown on the plans, Schedule 3 from Table 1 and Table 2 will be used to determine the level of payment adjustment for each 0.1-mi. section on the project.

No payment adjustment will be paid for any 0.1-mi. section that contains localized roughness.

3.4.2.2. **IRI Deficient 0.1-mi. Sections**. When payment adjustment Schedule 1 or 2 is specified, correct any 0.1-mi. section with an average IRI over 95.0 in. per mile. Correct the deficient section to an IRI of 65 in. per mile or less when Schedule 1 is specified or correct to an IRI of 75 in. per mile or less when Schedule 2 is specified. No corrective action is required for Schedule 3. After making corrections, reprofile the pavement section to verify that corrections have produced the required improvements.

The associated payment adjustment shown in Table 1 applies when successful corrective action improves the IRI of a deficient 0.1-mi. section.

If corrective action does not produce the required improvement, the Engineer may require:

- continued corrective action, or
- apply the pertinent payment adjustment shown in Table 2 if the reprofiled IRI is greater than 65 in. per mile.

3.4.2.2.1. **Corrective Action**. Use diamond grinding or other approved work methods to correct any deficient 0.1-mi. section. For asphalt concrete pavements, fog seal the aggregate exposed from diamond grinding or other approved work methods allowed.

3.4.2.3. **Localized Roughness**. Measure localized roughness using an inertial profiler in accordance with Tex-1001-S. The Engineer will determine areas of localized roughness using the individual profile from each wheel path.

Use a 10-ft. straightedge, when allowed, to locate areas that have more than 1/8-in. variation between any 2 contacts on the straightedge when Schedule 3 is specified.

The Engineer may waive localized roughness requirements for deficiencies resulting from manholes or other similar appurtenances near the wheel paths.

3.4.2.3.1. **Corrective Action**. Use diamond grinding or other approved work methods to correct localized roughness. For asphalt concrete pavements, fog seal the aggregate exposed from diamond grinding or other approved work methods allowed. Reprofile the corrected area, and provide results that show the corrective action was successful. If the corrective action is not successful, the Engineer will require continued corrective action or apply a localized roughness payment adjustment.

3.4.2.3.2. **Localized Roughness** Payment Adjustment. Instead of continued corrective action, the Engineer may assess a payment adjustment for each occurrence of localized roughness. No more than one payment adjustment will be applied for any 5 ft. of longitudinal distance. For Schedule 1, a localized roughness payment adjustment of $500 per occurrence will be applied. For Schedule 2, a localized roughness payment adjustment of $250 per occurrence will be applied. For Schedule 3, a localized roughness payment adjustment will not be applied.

Localized roughness payment adjustments will be evaluated within 0.1-mi. sections and applied unless the IRI deficient 0.1-mi. section payment adjustment is greater. When the IRI deficient payment adjustment is greater, the payment adjustment in Table 2 will be applied.

4. MEASUREMENT AND PAYMENT

The work performed, materials furnished, certification and recertification, traffic control for all testing, materials and work needed for corrective action, equipment, labor, tools, and incidentals will not be measured or paid for directly but will be subsidiary to pertinent Items. Sections shorter than 0.1 mi. and longer than 50 ft. will be prorated in accordance with Tex-1001-S.

Table 1
Payment Adjustments for Ride Quality

Average IRI for each 0.10 mi. of Traffic Lane	Payment Adjustment $/0.10 mi. of Traffic Lane	
(in./mi.)	Schedule 1 and Schedule 2	Schedule 3
≤ 30	600	300
31	580	290
32	560	280
33	540	270
34	520	260
35	500	250
36	480	240
37	460	230
38	440	220
39	420	210
40	400	200
41	380	190
42	360	180
43	340	170
44	320	160
45	300	150
46	280	140
47	260	130
48	240	120
49	220	110
50	200	100
51	180	90
52	160	80
53	140	70
54	120	60
55	100	50
56	80	40
57	60	30
58	40	20
59	20	10
60 to 65	0	0

Table 2
Payment Adjustments for Ride Quality

Average IRI for each 0.10 mi. of Traffic Lane	**Payment Adjustment** $/0.10 mi. of Traffic Lane	
(in./mi.)	**Schedule 1**	**Schedule 2**
66	-20	0
67	-40	0
68	-60	0
69	-80	0
70	-100	0
71	-120	0
72	-140	0
73	-160	0
74	-180	0
75	-200	0
76	-220	-20
77	-240	-40
78	-260	-60
79	-280	-80
80	-300	-100
81	-320	-120
82	-340	-140
83	-360	-160
84	-380	-180
85	-400	-200
86	-420	-220
87	-440	-240
88	-460	-260
89	-480	-280
90	-500	-300
91	-520	-320
92	-540	-340
93	-560	-360
94	-580	-380
95	-600	-400
> 95	-3,000	

Item 662
Work Zone Pavement Markings

1. DESCRIPTION

Furnish, place, and maintain work zone pavement markings.

2. MATERIALS

Provide thermoplastic, paint and beads, raised pavement markers (RPMs), prefabricated pavement markings, temporary flexible reflective roadway marker tabs, or other approved materials for work zone pavement markings.

Supply materials meeting:

- DMS-4200, "Pavement Markers (Reflectorized),"
- DMS-4300, "Traffic Buttons,"
- DMS-8200, "Traffic Paint,"
- DMS-8220, "Hot Applied Thermoplastic,"
- DMS-8240, "Permanent Prefabricated Pavement Markings,"
- DMS-8241, "Temporary (Removable) Prefabricated Pavement Markings,"
- DMS-8242, "Temporary Flexible, Reflective Roadway Marker Tabs," and
- DMS-8290, "Glass Traffic Beads."

2.1. **Nonremovable Markings**. Use hot-applied thermoplastic or permanent prefabricated pavement markings for nonremovable markings. Paint and beads or other materials are not allowed for nonremovable markings unless shown on the plans.

2.2. **Removable and Short-Term Markings**. Use RPMs, removable prefabricated pavement markings, temporary flexible reflective roadway marker tabs, or other approved materials for removable and short-term markings. Do not use hot-applied thermoplastic or traffic paint for removable markings. Use removable prefabricated pavement markings on the final pavement surface when the plans specify removable markings.

3. CONSTRUCTION

Apply pavement markings in accordance with the following Items.

- Item 666, "Retroreflectorized Pavement Markings"
- Item 668, "Prefabricated Pavement Markings"
- Item 672, "Raised Pavement Markers"

3.1. **Placement**. Install longitudinal markings on pavement surfaces before opening to traffic. Maintain lane alignment traffic control devices and operations until markings are installed. Install markings in proper alignment in accordance with the TMUTCD and as shown on the plans. Short-term markings will be allowed when standard markings (removable or nonremovable) cannot be placed before opening to traffic, if shown on the plans or directed.

When short-term markings are allowed for opening to traffic, place standard longitudinal markings no later than 14 calendar days after the placement of the surface. When inclement weather prohibits placement of markings, the 14-day period may be extended until weather permits proper application.

Place standard longitudinal markings no sooner than 3 calendar days after the placement of a surface treatment, unless otherwise shown on the plans.

Apply thermoplastic markings to a minimum thickness of 0.060 in. (60 mils). When paint and beads are allowed, apply to a minimum dry thickness of 0.012 in. (12 mils).

Place short-term markings in proper alignment with the location of the final pavement markings. Remove and replace short-term markings not in alignment at the Contractor's expense.

For removable placements, use of RPMs to simulate longitudinal markings is at the Contractor's option. Use side-by-side RPMs to simulate longitudinal lines wider than 4 in. Do not use RPMs for words, symbols, shapes, or diagonal or transverse lines.

3.2. **Marking Removal**. Remove markings that conflict with succeeding markings in accordance with Item 677, "Eliminating Existing Pavement Markings and Markers." Remove short-term markings that interfere or conflict with final marking placement immediately before placing final pavement markings, unless otherwise directed. Remove the remainder of the short-term markings before final acceptance.

Remove all temporary markings with minimal damage to the roadway to the satisfaction of the Engineer.

3.3. **Performance Requirements**. Ensure all markings are visible from a distance at least 300 ft. in daylight conditions and at least 160 ft. in nighttime conditions when illuminated by automobile low-beam headlights. Determine visibility distances using an automobile traveling on the roadway under dry conditions.

Maintain the markings for 30 calendar days after installation. The end of the 30-day maintenance period does not relieve the Contractor from the performance deficiencies requiring corrective action identified during the 30-day period. Remove and replace markings at the Contractor's expense if they fail to meet the requirements of this Item during the 30-day period. The 30-calendar day performance requirement will begin again after replacement of the markings.

Ensure daytime and nighttime reflected color of the markings are distinctly white or yellow. Ensure markings exhibit uniform retroreflective characteristics.

4. MEASUREMENT

This Item will be measured by the foot or each word, shape, symbol, or temporary flexible reflective roadway marker tab. Each stripe will be measured separately. RPMs used to simulate a marking will be measured by the foot of marking or each RPM.

This is a plans quantity measurement Item. The quantity to be paid is the quantity shown in the proposal, unless modified by Article 9.2., "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Work Zone Pavement Markings" of the type and color specified and the shape, width, and size specified as applicable. This price is full compensation for furnishing, placing, maintaining, and removing work zone pavement markings and for materials, equipment, labor, tools, and incidentals.

Elimination of nonremovable markings will be paid for under Item 677, “Eliminating Existing Pavement Markings and Markers.” Removal of short-term and removable markings will not be paid for directly but will be subsidiary to this Item.

Type II work zone pavement markings (paint and beads) used as a sealer for Type I pavement markings (thermoplastic) will be paid for under this Item.

Item 666
Retroreflectorized Pavement Markings

1. DESCRIPTION

Furnish and place retroreflectorized, non-retroreflectorized (shadow) and profile pavement markings.

2. MATERIALS

2.1. **Type I Marking Materials**. Furnish in accordance with DMS-8220, "Hot Applied Thermoplastic."

Furnish pavement marking material used for Type I profile markings and shadow markings that have been approved by the Construction Division, and in accordance with DMS-8220, "Hot Applied Thermoplastic."

2.2. **Type II Marking Materials**. Furnish in accordance with DMS-8200, "Traffic Paint."

2.3. **Glass Traffic Beads**. Furnish drop-on glass beads in accordance with DMS-8290, "Glass Traffic Beads" or as approved. Furnish a double-drop of Type II and Type III drop-on glass beads where each type bead is applied separately in equal portions (by weight), unless otherwise approved. Apply the Type III beads before applying the Type II beads.

2.4. **Labeling**. Use clearly marked containers that indicate color, mass, material type, manufacturer, and batch number.

3. EQUIPMENT

3.1. **General Requirements**. Use equipment that:

- is maintained in satisfactory condition,
- meets or exceeds the requirements of the National Board of Fire Underwriters and the Texas Railroad Commission for this application,
- applies beads by an automatic bead dispenser attached to the pavement marking equipment in such a manner that the beads are dispensed uniformly and almost instantly upon the marking as the marking is being applied to the road surface. The bead dispenser must have an automatic cut-off control, synchronized with the cut-off of the pavement marking equipment,
- has an automatic cut-off device with manual operating capabilities to provide clean, square marking ends,
- is capable of producing the types and shapes of profiles specified, and
- can provide continuous mixing and agitation of the pavement marking material. The use of pans, aprons, or similar appliances which the die overruns will not be permitted for longitudinal striping applications.

Provide a hand-held thermometer capable of measuring the temperature of the marking material when applying Type I material.

When pavement markings are required to meet minimum retroreflectivity requirements on the plans:

- Use a mobile retroreflectometer approved by the Construction Division and certified by the Texas A&M Transportation Institute Mobile Retroreflectometer Certification Program.
- Use a portable retroreflectometer that:
  - uses 30-meter geometry and meets the requirements described in ASTM E1710;

- has either an internal global positioning system (GPS) or the ability to be linked with an external GPS with a minimum accuracy rating of 16 ft. 5 in., in accordance with the circular error probability (CEP) method (CEP is the radius of the circle with its origin at a known position that encompasses 50% of the readings returned from the GPS instrument);
- can record and print the GPS location and retroreflectivity reading for each location where readings are taken.

3.2. **Material Placement Requirements**. Use equipment that can place:

- at least 40,000 ft. of 4-in. solid or broken non-profile markings per working day at the specified thickness;
- at least 15,000 ft. of solid or broken profile pavement markings per working day at the specified thickness;
- linear non-profile markings up to 8 in. wide in a single pass;
- non-profile pavement markings other than solid or broken lines at an approved production rate;
- a centerline and no-passing barrier-line configuration consisting of 1 broken line and 2 solid lines at the same time to the alignment, spacing, and thickness for non-profile pavement markings shown on the plans;
- solid and broken lines simultaneously;
- white line from both sides;
- lines with clean edges, uniform cross-section with a tolerance of ±1/8 in. per 4 in. width, uniform thickness, and reasonably square ends;
- skip lines between 10 and 10-1/2 ft., a stripe-to-gap ratio of 10 to 30, and a stripe-gap cycle between 39-1/2 ft. and 40-1/2 ft., automatically;
- beads uniformly and almost instantly on the marking as the marking is being applied;
- beads uniformly during the application of all lines (each line must have an equivalent bead yield rate and embedment); and
- double-drop bead applications using both Type II and Type III beads from separate independent bead applicators, unless otherwise approved by the Engineer.

4. CONSTRUCTION

Place markings before opening to traffic unless short-term or work zone markings are allowed.

4.1. **General**. Obtain approval for the sequence of work and estimated daily production. Minimize interference to roadway operations when placing markings on roadways open to traffic. Use traffic control as shown on the plans or as approved. Protect all markings placed under open-traffic conditions from traffic damage and disfigurement.

Establish guides to mark the lateral location of pavement markings as shown on the plans or as directed, and have guide locations verified. Use material for guides that will not leave a permanent mark on the roadway.

Apply markings on pavement that is completely dry and passes the following tests:

- Type I Marking Application—Place a sample of Type I marking material on a piece of tarpaper placed on the pavement. Allow the material to cool to ambient temperature, and then inspect the underside of the tarpaper in contact with the pavement. Pavement will be considered dry if there is no condensation on the tarpaper.
- Type II Marking Application—Place a 1-sq. ft. piece of clear plastic on the pavement, and weight down the edges. The pavement is considered dry if, when inspected after 15 min., no condensation has occurred on the underside of the plastic.

Apply markings:

- that meet the requirements of Tex-828-B,
- that meet minimum retroreflectivity requirements when specified on the plans (applies to Type I markings only),
- using widths and colors shown on the plans,
- at locations shown on the plans,
- in proper alignment with the guides without deviating from the alignment more than 1 in. per 200 ft. of roadway or more than 2 in. maximum,
- without abrupt deviations,
- free of blisters and with no more than 5% by area of holes or voids,
- with uniform cross-section, density and thickness,
- with clean and reasonably square ends,
- that are retroreflectorized with drop-on glass beads, and
- using personnel skilled and experienced with installation of pavement markings.

Remove all applied markings that are not in alignment or sequence as stated on the plans, or in the specifications, at the Contractor's expense in accordance with Item 677, "Eliminating Existing Pavement Markings and Markers," except for measurement and payment.

4.2. **Surface Preparation**. Prepare surfaces in accordance with this Section unless otherwise shown on the plans.

4.2.1. **Cleaning for New Asphalt Surfaces and Retracing of All Surfaces**. Air blast or broom the pavement surface for new asphalt surfaces (less than 3 years old) and for retracing of all surfaces to remove loose material, unless otherwise shown on the plans. A sealer for Type I markings is not required unless otherwise shown on the plans.

4.2.2. **Cleaning for Old Asphalt and Concrete Surfaces (Excludes Retracing)**. Clean old asphalt surfaces (more than 3 years old) and all concrete surfaces in accordance with Item 678, "Pavement Surface Preparation for Markings," to remove curing membrane, dirt, grease, loose and flaking existing construction markings, and other forms of contamination.

4.2.3. **Sealer for Type I Markings**. Apply a pavement sealer to old asphalt surfaces (more than 3 years old) and to all concrete surfaces before placing Type I markings on locations that do not have existing markings, unless otherwise approved. The pavement sealer may be either a Type II marking or an acrylic or epoxy sealer as recommended by the Type I marking manufacturer unless otherwise shown on the plans. Follow the manufacturer's directions for application of acrylic or epoxy sealers. Clean sealer that becomes dirty after placement by washing or in accordance with Section 666.4.2.1., "Cleaning for New Asphalt Surfaces and Retracing of All Surfaces," as directed. Place the sealer in the same configuration and color (unless clear) as the Type I markings unless otherwise shown on the plans.

4.3. **Application**. Apply markings during good weather unless otherwise directed. If markings are placed at Contractor option when inclement weather is impending and the markings are damaged by subsequent precipitation, the Contractor is responsible for all required replacement costs.

4.3.1. **Type I Markings**. Place the Type I marking after the sealer cures. Apply within the temperature limits recommended by the material manufacturer. Flush the spray head if spray application operations cease for 5 min or longer by spraying marking material into a pan or similar container until the material being applied is at the recommended temperature.

Apply on clean, dry pavements passing the moisture test described in Section 666.4.1., "General," and with a surface temperature above 50°F when measured in accordance with Tex-829-B.

4.3.1.1. **Non-Profile Pavement Markings**. Apply Type I non-profile markings with a minimum thickness of:

- 0.100 in. (100 mils) for new markings and retracing water-based markings on surface treatments involving Item 316, "Seal Coat,"
- 0.060 in. (60 mils) for retracing on thermoplastic pavement markings, or
- 0.090 in. (90 mils) for all other Type I markings.

The maximum thickness for Type I non-profile markings is 0.180 in. (180 mils). Measure thickness for markings in accordance with Tex-854-B using the tape method.

4.3.1.2. **Profile Pavement Markings**. Apply Type I profile markings with a minimum thickness of:

- 0.060 in. (60 mil) for edgeline markings, or
- 0.090 in. (90 mil) for gore and centerline/no-passing barrier line markings.

In addition, at a longitudinal spacing indicated on the plans, the markings must be profiled in a vertical manner such that the profile is transverse to the longitudinal marking direction. The profile must not be less than 0.30 in. (300 mil) nor greater than 0.50 in. (500 mil) in height when measured above the normal top surface plane of the roadway. The transverse width of the profile must not be less than 3.25 in., and the longitudinal width not less than 1 in., when measured at the top surface plane of the profile bar. The profile may be either a 1 or 2 transverse bar profile. When the 2 transverse bar profile is used, the spacing between the bases of the profile bars must not exceed 0.50 in. The above transverse bar width is for each 4 in. of line width.

4.3.2. **Type II Markings**. Apply on surfaces with a minimum surface temperature of 50°F. Apply at least 20 gal. per mile on concrete and asphalt surfaces and at least 22 gal. per mile on surface treatments for a solid 4-in. line. Adjust application rates proportionally for other widths. When Type II markings are used as a sealer for Type I markings, apply at least 15 gal. per mile using Type II drop-on beads.

4.3.3. **Bead Coverage**. Provide a uniform distribution of beads across the surface of the stripe for Type I and Type II markings, with 40% to 60% bead embedment.

4.4. **Retroreflectivity Requirements**. When specified on the plans, Type I markings must meet the following minimum retroreflectivity values for edgeline markings, centerline or no passing barrier-line, and lane lines when measured any time after 3 days, but not later than 10 days after application:

- White markings: 250 millicandelas per square meter per lux (mcd/m^2/lx)
- Yellow markings: 175 mcd/m^2/lx

4.5. **Retroreflectivity Measurements**. Use a mobile retroreflectometer for projects requiring minimum retroreflectivity requirements to measure retroreflectivity for Contracts totaling more than 200,000 ft. of pavement markings, unless otherwise shown on the plans. For Contracts with less than 200,000 ft. of pavement markings or Contracts with callout work, mobile or portable retroreflectometers may be used at the Contractor's discretion.

4.5.1. **Mobile Retroreflectometer Measurements**. Provide mobile measurements averages for every 0.1 miles unless otherwise specified or approved. Take measurements on each section of roadway for each series of markings (i.e., edgeline, center skip line, each line of a double line, etc.) and for each direction of traffic flow. Measure each line in both directions for centerlines on two-way roadways (i.e., measure both double solid lines in both directions and measure all center skip lines in both directions). Furnish measurements in compliance with Special Specification, "Mobile Retroreflectivity Data Collection for Pavement Markings," unless otherwise approved. The Engineer may require an occasional field comparison check with a portable retroreflectometer meeting the requirements listed above to ensure accuracy. Use all equipment in accordance with the manufacturer's recommendations and directions. Inform the Engineer at least 24 hr. before taking any measurements.

A marking meets the retroreflectivity requirements if:

- the combined average retroreflectivity measurement for a one-mile segment meets the minimum retroreflectivity values specified, and
- no more than 30% of the retroreflectivity measurement values are below the minimum retroreflectivity requirements value within the one-mile segment.

The Engineer may accept failing one-mile segments if no more than 20% of the retroreflectivity measurements within that mile segment are below the minimum retroreflectivity requirement value.

The one-mile segment will start from the beginning of the data collection and end after a mile worth of measurements have been taken; each subsequent mile of measurements will be a new segment. Centerlines with 2 stripes (either solid or broken) will result in 2 miles of data for each mile segment. Each centerline stripe must be tested for compliance as a stand-alone stripe.

Restripe at the Contractor's expense with a minimum of 0.060 in. (60 mils) of Type I marking if the marking fails retroreflectivity requirements. Take measurements every 0.1 miles a minimum of 10 days after this second application within that mile segment for that series of markings.

If the markings do not meet minimum retroreflectivity after 10 days of this second application, the Engineer may require removal of all existing markings, a new application as initially specified, and a repeat of the application process until minimum retroreflectivity requirements are met.

4.5.2. **Portable Retroreflectometer Measurements**. Take a minimum of 20 measurements for each 1-mi. section of roadway for each series of markings (i.e., edgeline, center skip line, each line of a double line, etc.) and direction of traffic flow when using a portable reflectometer. Measure each line in both directions for centerlines on two-way roadways (i.e., measure both double solid lines in both directions and measure all center skip lines in both directions). The spacing between each measurement must be at least 100 ft. The Engineer may decrease the mileage frequency for measurements if the previous measurements provide satisfactory results. The Engineer may require the original number of measurements if concerns arise.

Restripe once at the Contractor's expense with a minimum of 0.060 in. (60 mils) of Type I marking material if the average of these measurements fails. Take a minimum of 10 more measurements after 10 days of this second application within that mile segment for that series of markings. Restripe again at the Contractor's expense with a minimum of 0.060 in. (60 mils) of Type I marking material if the average of these measurements fall below the minimum retroreflectivity requirements. If the markings do not meet minimum retroreflectivity after this third application, the Engineer may require removal of all existing markings, a new application as initially specified, and a repeat of the application process until minimum retroreflectivity requirements are met.

4.5.3. **Traffic Control**. Provide traffic control, as required, when taking retroreflectivity measurements after marking application. On low volume roadways (as defined on the plans), refer to the figure, “Temporary Road Closure” in Part 6 of the *Texas Manual on Uniform Traffic Control Devices* for the minimum traffic control requirements. For all other roadways, the minimum traffic control requirements will be as shown on the Traffic Control Plan (TCP) standard sheets TCP (3-1) and TCP (3-2). The lead vehicle will not be required on divided highways. The TCP and traffic control devices must meet the requirements listed in Item 502, “Barricades, Signs, and Traffic Handling.” Time restrictions that apply during striping application will also apply during the retroreflectivity inspections except when using the mobile retroreflectometer unless otherwise shown on the plans or approved.

4.6. **Performance Period**. All markings must meet the requirements of this specification for at least 30 calendar days after installation. Unless otherwise directed, remove pavement markings that fail to meet requirements, and replace at the Contractor’s expense. Replace failing markings within 30 days of notification. All replacement markings must also meet all requirements of this Item for a minimum of 30 calendar days after installation.

5. MEASUREMENT

This Item will be measured by the foot; by each word, symbol, or shape; or by any other unit shown on the plans. Each stripe will be measured separately.

This is a plans quantity measurement item. The quantity to be paid is the quantity shown in the proposal unless modified by Article 9.2., "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.

Acrylic or epoxy sealer, or Type II markings when used as a sealer for Type I markings, will be measured by the foot; by each word, symbol, or shape; or by any other unit shown on the plans.

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Pavement Sealer" of the size specified, "Retroreflectorized Pavement Markings" of the type and color specified and the shape, width, size, and thickness specified as applicable, "Retroreflectorized Pavement Markings with Retroreflective Requirements" of the types, colors, sizes, widths, and thicknesses specified or "Retroreflectorized Profile Pavement Markings" of the various types, colors, shapes, sizes, and widths specified.

This price is full compensation for application of pavement markings, materials, equipment, labor, tools, and incidentals.

Surface preparation of new concrete and asphalt concrete pavements more than 3 years old, where no stripe exists, will be paid for under Item 678, "Pavement Surface Preparation for Markings." Surface preparation of all other asphalt and old concrete pavement, except for sealing, will not be paid for directly but is subsidiary to this Item.

Work zone pavement markings (Type II, paint and beads) used as a sealer for Type I markings (thermoplastic) will be paid for under Item 662, "Work Zone Pavement Markings."

If the Engineer requires that markings be placed in inclement weather, repair or replacement of markings damaged by the inclement weather will be paid for in addition to the original plans quantity.

Item 677
Eliminating Existing Pavement Markings and Markers

1. DESCRIPTION

Eliminate existing pavement markings and raised pavement markers (RPMs).

2. MATERIALS

Furnish surface treatment materials in accordance with the following Items:

- Item 300, “Asphalts, Oils, and Emulsions”
- Item 302, “Aggregates for Surface Treatments”
- Item 316, “Seal Coat”

Use approved patching materials for repairing damaged surfaces.

Use a commercial abrasive blasting medium capable of producing the specified surface cleanliness. Use potable water when water is required.

3. EQUIPMENT

Furnish and maintain equipment in good working condition. Use moisture and oil traps in air compression equipment to remove all contaminants from the blasting air and prevent the deposition of moisture, oil, or other contaminants on the roadway surface.

4. CONSTRUCTION

Eliminate existing pavement markings and markers on both concrete and asphaltic surfaces in such a manner that color and texture contrast of the pavement surface will be held to a minimum. Remove all markings and markers with minimal damage to the roadway to the satisfaction of the Engineer. Repair damage to asphaltic surfaces, such as spalling, shelling, etc., greater than 1/4 in. deep resulting from the removal of pavement markings and markers. Dispose of markers in accordance with federal, state, and local regulations. Use any of the following methods unless otherwise shown on the plans:

4.1. **Surface Treatment Method**. Apply surface treatment material at rates shown on the plans, or as directed. Place a surface treatment a minimum of 2 ft. wide to cover the existing marking. Place a surface treatment, thin overlay, or microsurfacing a minimum of one lane in width in areas where directional changes of traffic are involved or other areas as directed.

4.2. **Burn Method**. Use an approved burning method. For thermoplastic pavement markings or prefabricated pavement markings, heat may be applied to remove the bulk of the marking material before blast cleaning. When using heat, avoid spalling pavement surfaces. Sweeping or light blast cleaning may be used to remove minor residue.

4.3. **Blasting Method**. Use a blasting method such as water blasting, abrasive blasting, water abrasive blasting, shot blasting, slurry blasting, water-injected abrasive blasting, or brush blasting as approved. Remove pavement markings on concrete surfaces by a blasting method.

4.4. **Mechanical Method**. Use any mechanical method except grinding. Flail milling is acceptable in the removal of markings on asphalt and concrete surfaces.

5. MEASUREMENT

This Item will be measured by each word, symbol, or shape eliminated; by the foot of marking eliminated; or by any other unit shown on the plans.

This is a plans quantity measurement Item. The quantity to be paid is the quantity shown in the proposal unless modified by Article 9.2., "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Eliminating Existing Pavement Markings and Markers" of the type and width as applicable. This price is full compensation for the elimination method used and materials, equipment, tools, labor, and incidentals. Removal of RPMs will not be paid for directly but will be subsidiary to the pertinent bid items.

Item 678
Pavement Surface Preparation for Markings

1. DESCRIPTION

Prepare pavement surface areas before placement of pavement markings and raised pavement markers (RPMs). Item 677, "Eliminating Existing Pavement Markings and Markers," governs removal of existing markings.

2. MATERIALS

Use a commercial abrasive blasting medium capable of producing the specified surface cleanliness. Use potable water, when water is required.

3. EQUIPMENT

Furnish and maintain equipment in good working condition. Use moisture and oil traps in air compression equipment to remove all contaminants from the blasting air and prevent the deposition of moisture, oil, or other contaminants on the roadway surface.

4. CONSTRUCTION

Prepare enough pavement surface for the pavement markings or RPMs shown on the plans. Remove all contamination and loose material. Avoid damaging the pavement surface. Remove loose and flaking material when existing pavement markings are present. Approved pavement surface preparation methods are sweeping, air blasting, flail milling, and blast cleaning unless otherwise specified on the plans.

Air blast concrete pavement surfaces, in addition to the above, after the removal of contamination or existing material and just before placing the stripe. Perform air blasting with a compressor capable of generating compressed air at a minimum of 150 cu. ft. per minute and 100 psi using 5/16 in. or larger hosing.

Contaminants up to 0.5 sq. in. may remain if they are not removed by the following test, performed just before application of markings:

- **Step 1**. Air blast the surface to be tested, to simulate blasting during application of markings.
- **Step 2**. Firmly press a 10-in. long, 2-in. wide strip of monofilament tape onto the surface, leaving approximately 2 in. free.
- **Step 3**. Grasp the free end and remove the tape with a sharp pull.

5. MEASUREMENT

This Item will be measured by the foot for each width specified; by each word, shape, or symbol; or by any other unit except lump sum.

This is a plans quantity measurement Item. The quantity to be paid is the quantity shown in the proposal, unless modified by Article 9.2., "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Pavement Surface Preparation for Markings" of the type and width as applicable. This price is full compensation for the cleaning method used, materials, equipment, labor, tools, and incidentals.

Item 700
Pothole Repair

1. DESCRIPTION

Repair potholes, spalled areas, depressions, and raveled or damaged pavement edges in roadway surfaces.

2. MATERIALS

Furnish materials, unless otherwise shown on the plans. Use materials that meet the requirements of the following Items, as shown on the plans.

- Item 300, "Asphalt, Oils, and Emulsions,"
- Item 330, "Limestone Rock Asphalt Pavement,"
- Item 334, "Hot-Mix Cold-Laid Asphalt Concrete Pavement,"
- Item 340, "Dense-Graded Hot-Mix Asphalt (Small Quantity),"
- DMS-9202, "Asphaltic Concrete Patching Material (Stockpile Storage or Bagged),"
- DMS-9203, "Rapid-Curing Asphaltic Concrete Patching Material (Containerized)," and
- DMS-9204, "Fiber Additives for Bituminous Mixtures."

3. WORK METHODS

Work requests are made on a callout basis. Begin physical repair within 24 hr. of notification, 3 hr. if emergency mobilization is required, unless otherwise shown on the plans.

3.1. **Standard Repair**. Remove loose and foreign materials from the repair area. Remove water, dry, and apply tack coat to surfaces of the repair area unless otherwise directed.

Place repair material in horizontal lifts as directed. Finish to grade and compact to conform to roadway surface. Compact with hand tamp, mechanical tampers, or rollers as directed or approved. Compact to achieve full consolidation.

Repair pavement edges to the line and grade of original pavement. Clean roadway surface after repair operations. Dispose of materials removed as directed or approved.

3.2. **Saw-Cut Repair**. Square the sides of the repair area by saw-cutting or other approved methods. Remove loose and foreign material. Clean and dry the repair area. Apply tack coat to surfaces of the repair area unless otherwise directed.

Place repair material in horizontal lifts no more than 3 in. deep. Finish to grade and compact to conform to roadway surface. Compact with hand tamp, mechanical tampers, or rollers as directed or approved. Compact to achieve full consolidation.

Repair pavement edges to the line and grade of original pavement. Clean roadway surface after repair operations. Dispose of materials removed as directed or approved.

4. MEASUREMENT

Emergency mobilization will be measured by each emergency work request. Pothole repair will be measured by the square yard of surface area or by the cubic yard, ton, or pound of material used. For Contracts with

callout work without emergency mobilization, the minimum quantity per callout respectively is 5 sq. yd., 1/2 cu. yd., 1/2 ton, or 150 lb., unless otherwise shown on the plans.

4.1. **Area**. The surface area of repairs will be measured.

4.2. **Volume**. Trucks will be measured and the loose volume in cubic yards will be calculated for legally transported loads. Level the load for measurement before beginning work. Level off the material remaining on the last load for measurement. Material not used at the end of the day will be deducted from the volume.

4.3. **Weight (Ton)**. Trucks will be weighed on certified scales. Provide weight tickets. Material not used at the end of the day will be deducted from the weight. Measurement will be in accordance with Item 520, "Weighing and Measuring Equipment."

4.4. **Weight (Pound)**. Materials furnished in a container will be measured by the pound as shown on the container.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit prices bid for "Pothole Repair (Standard)" or "Pothole Repair (Saw-Cut)" and "Emergency Mobilization," if required. The price bid for pothole repair is full compensation for furnishing materials, unless otherwise shown on the plans; application of the tack coat; removal and disposal of debris and excess material; leveling off or weighing the load for measurement; and equipment, labor, tools, and incidentals.

The price bid for emergency mobilization is full compensation for beginning physical work within 3 hr. of notification. Emergency mobilization will be paid for in addition to pothole repair.

Item 712

Cleaning and Sealing Joints and Cracks (Asphalt Concrete)

1. DESCRIPTION

Clean and seal joints and cracks in asphalt concrete roadway surfaces.

2. MATERIALS

Furnish materials unless otherwise shown on the plans. Furnish sealant materials as shown on the plans in accordance with Item 300, "Asphalts, Oils, and Emulsions." Furnish fine aggregate in accordance with Section 340.2.1.3., "Fine Aggregate."

3. EQUIPMENT

Furnish equipment, tools, and machinery for proper execution of the work.

3.1. **Hot-Applied Sealants**. Heat in a double-jacketed heater using a heat transfer oil so no direct flame comes in contact with the shell of the vessel containing the sealing compound. Provide a heater capable of circulating and agitating the sealant during the heating process to achieve a uniform temperature rise and maintain the desired temperature. Provide gauges to monitor the temperature of the vessel contents and avoid overheating the material. Provide a heater equipped with a gear-driven asphalt pump with adequate pressure to dispense the sealant.

3.2. **Cold-Applied Sealants**. Provide equipment with adequate pressure to dispense the sealant in a continuous flow.

4. WORK METHODS

Apply material when the air or pavement temperature is within the manufacturer's recommendations or as approved. Clean and seal joints and cracks that are 1/16 in. or greater in width. Fill cracks with dry sand for cracks greater than 1/2 in. or as shown on the plans. Rout joints and cracks to the configuration shown on the plans when required. Clean joints and cracks with air blast cleaning or other acceptable methods to a depth at least twice the joint or crack width. Joints and cracks must be free of moisture before sealing. Dispose of materials removed as directed or approved. Apply sealing material with a pressure nozzle. Completely fill cracks and joints. Squeegee material to no more than 3 in. wide and 1/8 in. above the pavement surface. Prevent tracking with an application of fine aggregate as directed.

5. MEASUREMENT

This Item will be measured by the foot, gallon, pound, or lane mile. Shoulders wider than 6 ft. are considered additional lanes.

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Joint and Crack Sealing" of the sealant material specified and "Joint and Crack Routing and Sealing" of the sealant material specified. This price is full

compensation for routing, cleaning, and sealing joints and cracks; furnishing and placing materials; and equipment, labor, tools, and incidentals.

If measurement is by the lane mile, shoulders 6 ft. or narrower will not be paid for directly but will be subsidiary to work on the adjacent travel lane.

Item 713

Cleaning and Sealing Joints and Cracks (Concrete Pavement)

1. DESCRIPTION

Clean and seal joints and cracks in concrete pavement.

2. MATERIALS

Furnish sealant, boards, and backer rods in accordance with DMS-6310, "Joint Sealants and Fillers." The sealant must be type 4, 5, 7, or 8 unless otherwise shown on the plans and specifications. Furnish primer when required by the sealant manufacturer.

3. EQUIPMENT

Use equipment that meets the sealant manufacturer's recommendations. Furnish equipment capable of placing the sealant, backer rods, and boards as detailed on the plans. Furnish equipment capable of removing all foreign material from the concrete joint or the grooved crack. The following equipment is recommended to meet cleaning and sealing requirements:

- Power Concrete Saw,
- Sandblasting Equipment,
- Power Router,
- High Pressure Air, and
- Sealant Dispenser.

4. WORK METHODS

Use dimensions shown for joint details in standard drawing *Concrete Paving Details, Joint Seals,* unless other dimensions are shown on the plans. Make a groove, follow the cracks to be sealed, and rout the groove approximately 1/2 in. deep × 5/8 in. wide, unless otherwise directed or shown on the plans. The Engineer will select joints and cracks to be cleaned and sealed.

Remove all foreign material from the joint or groove reservoir. Clean the joint by sandblasting or other approved methods. If directed, saw joint sides to remove embedded foreign material in the concrete that sandblasting will not remove. Do not place sealant when the concrete pavement is below 55°F or above 90°F. Do not place sealant in a wet or damp joint or groove. Use approved drying method if joints or grooves are sealed within 24 hours of rain. Apply primer when required by the sealant manufacturer. Blow out joint or groove with high pressure air or other approved methods before placing sealant. Remove and replace sealant when placed flush with or above the pavement surface. The different types of joints and cracks are described in Table 1.

Table 1
Types of Joints and Cracks Requirements

Joint or Crack Type	Requirement
Transverse Contraction Joints	Backer rods and sealants
Longitudinal Contraction Joint	Sealant
Longitudinal Construction Joint	Sealant
Expansion Joints	Boards, backer rods, and sealant
Cracks in Jointed Concrete Pavement	Sealant

5. MEASUREMENT

Joint cleaning and sealing will be measured by the foot of joint cleaned and sealed. Crack cleaning and sealing will be measured by the foot of crack cleaned and sealed.

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured in accordance with "Measurement" will be paid for at the unit price bid for "Joint Sealing and Cleaning" of the type specified, or "Crack Cleaning and Sealing."

Item 730

Roadside Mowing

1. DESCRIPTION

Mow roadside vegetation.

2. EQUIPMENT

2.1. Mowers. Provide either rigid-frame mowers with a maximum cutting width of 9 ft. or batwing rotary mowers equipped with sharp blades to cleanly cut vegetation using deflection devices to prevent flying debris ejected by the mowers, unless otherwise shown on the plans.

2.2. Emblems. Provide slow-moving vehicle emblem affixed to rear of mowers.

2.3. Warning Lights. Provide highly visible omnidirectional amber flashing warning lights on tractors and work trucks.

2.4. Trimmers. Provide trimmers for hand trimming.

2.5. Portable Pressure Washer. Provide a portable pressure washer with a minimum operating pressure of 1,500 psi to wash mowing equipment when shown on the plans.

3. WORK METHODS

3.1. Requirements.

- Set mower cutting height 5 to 7 in. or as directed.
- Perform mowing sequence as directed or approved.
- Ensure wet ground is not mowed when rutting can occur, unless otherwise approved.
- Do not mow designated non-mow areas.
- Remove debris ejected onto the roadway immediately. Remove mowed grass from roadway when determined to be a hazard.
- Hand-trim around fixed objects within mowed area. Complete hand trimming on each roadway within 24 hr. of mowing. Ensure trees and shrubs are not damaged.
- Restore appurtenances damaged by mowing operations, in accordance with Article 7.17., “Contractor’s Responsibility for Work.”
- Ensure stands of wildflowers are not mowed before seeds have matured, unless otherwise directed.

3.2. Mowing Types.

3.2.1. Strip Mowing.

- Mow a strip of vegetation along edge of pavement or unpaved shoulder, in accordance with details shown on the plans.
- Mow to provide sight distance at horizontal curves, intersections, driveways, and ramps.
- Mow to right of way line where specified.
- Mow around appurtenances within the strip width.
- Mow entire right of way under bridges and in drainage channels.

- Provide a 6 to 1 transition between the strip width and other areas requiring a different width.
- Mow the entire width of medians and outer separations (areas between mainlanes, ramps, and frontage roads), except for non-mow areas.

3.2.2. Full-Width Mowing. Mow vegetation in the entire right of way, except for non-mow areas.

3.2.3. Spot Mowing. Work requests are made on a callout basis. Begin mowing designated areas within 48 hr. of notification unless otherwise shown on the plans.

3.3. Washing Mowing Equipment. Pressure wash mowing equipment before the equipment enters or leaves designated areas shown on the plans. Notify the inspector before washing the equipment. The inspector will approve the washing locations so seed and plant material is contained.

4. MEASUREMENT

This Item will be measured by the acre.

4.1. Strip and Full-Width Mowing. "Strip Mowing" and "Full-Width Mowing" are plans quantity measurement items. The quantity to be paid is the quantity shown on the plans, unless modified by Article 9.2., "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.

4.2. Spot Mowing. "Spot Mowing" will be measured by the acre mowed. The minimum quantity per callout is 3 acres, unless otherwise shown on the plans.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Strip Mowing," "Full-Width Mowing," or "Spot Mowing." This price is full compensation for furnishing and operating equipment; pressure washing; and materials, tools, and incidentals.

Item 734
Litter Removal

1. DESCRIPTION

Remove and dispose of litter, including objects not part of the highway facility, such as trash, garbage, scrap metal, paper, wood, plastic, glass products, animal remains, rubber products, tires, auto parts, furniture, mattresses, household appliances, and large bulky items.

2. MATERIALS

Furnish bags and containers.

3. EQUIPMENT

Provide equipment and tools. Provide highly visible omni-directional amber flashing warning lights on work vehicles. Provide equipment that prevents the accumulated debris from being strewn along the roadway during transport.

4. WORK METHODS

Remove bagged litter on the same day it is collected. Notify the Department for removal of dead animals larger than 150 lb. or hazardous materials. Dispose of litter off the right of way in accordance with federal, state, and local regulations. Perform litter removal and disposal according to the following types.

4.1. **Litter**. Remove and dispose of litter from the right of way, including shoulders but excluding the traveled lanes and shoulders next to barriers, to the limits shown on the plans.

4.2. **Spot Litter**. Work requests are made on a callout basis. Begin removing litter within 3 hr. of notification, unless otherwise shown on the plans.

5. MEASUREMENT

This Item will be measured as follows:

5.1. **Litter**. By the cycle or acre.

5.2. **Spot Litter**. By the acre. The minimum quantity per callout is 3 acres, unless otherwise shown on the plans.

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit prices bid for "Litter Removal" or "Litter Removal (Spot)." This price is full compensation for collecting, hauling, and disposing of litter; and for equipment, labor, materials, tools, and incidentals.

Item 735
Debris Removal

1. DESCRIPTION

Remove and dispose of debris discarded or deposited on or adjacent to the pavement. Debris includes all objects not part of the highway facility, such as dead animals, tires, tire fragments, wood, furniture, mattresses, household appliances, and scrap metal.

2. EQUIPMENT

Provide highly visible omni-directional flashing warning lights on work vehicles. Provide equipment that prevents the accumulated debris from being strewn along the roadway during transport.

3. WORK METHODS

Remove debris at locations shown on the plans. Notify the Department for removal of hazardous materials. Dispose of debris off the right of way in accordance with applicable federal, state, and local regulations.

3.1. **Center Medians and Mainlanes**. Remove and dispose of debris from the main travel lanes, paved medians, paved shoulders, and an additional 5 ft. adjacent to the pavement, unless otherwise shown on the plans.

3.2. **Frontage Roads**. Remove and dispose of debris from frontage roads, shoulders, U-turn lanes, and intersecting streets to the right of way, including turn lanes, underpasses and overpasses, and an additional 5 ft. adjacent to the pavement, unless otherwise shown on the plans.

3.3. **Entrance and Exit Ramps**. Remove and dispose of debris from ramps, shoulders, and an additional 5 ft. adjacent to the pavement, unless otherwise shown on the plans.

3.4. **High Occupancy Vehicle (HOV) Lane.** Remove and dispose of debris from HOV lanes including HOV ramps. The HOV lanes are defined as:

3.4.1. **Barrier-Separated Contraflow Lane.** Barrier-separated contraflow lane(s) is defined as a lane enclosed by two physical barriers.

3.4.2. **Buffer-Separated Concurrent Flow Lane.** Buffer-separated concurrent flow lane is separated from general purpose lanes by a striped buffer zone and is defined as the left or inner most lane identified by signing and diamond symbols on the pavement.

3.5. **Direct Connector Ramp Debris Removal.** Remove and dispose of debris from the shoulders and paved gutters of direct connector ramp.

3.6. **Spot Debris Removal**. Work requests are made on a callout basis. Remove and dispose of debris as directed. Begin removing debris within 3 hr. of notification, unless otherwise shown on the plans.

4. MEASUREMENT

This Item will be measured as follows:

4.1. **Center Medians and Mainlanes, Frontage Roads, and Entrance and Exit Ramps**. By the cycle or right of way centerline mile. A right of way centerline mile is defined as the distance from beginning reference marker location to ending reference marker location, regardless of the number of roadbeds.

4.2. **HOV Lane Debris Removal.** By the cycle or HOV lane centerline miles. HOV lane centerline mile is defined as the distance measured along each HOV lane regardless of the number of lanes.

4.3. **Direct Connector Ramp Debris Removal.** By the cycle or direct connector ramp centerline mile. A direct connector centerline mile is defined as the distance measured along each direct connector regardless of the number of lanes.

4.4. **Spot Debris Removal**. By the roadbed mile. The minimum quantity per callout is 1 roadbed mile, unless otherwise shown on the plans.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit prices bid for "Debris Removal" of the type and cycle location specified. This price is full compensation for collecting, hauling and disposing of debris, and for equipment, labor, materials, tools, and incidentals. Traffic control will not be paid for directly but will be subsidiary to this Item, unless otherwise shown on the plans.

Debris removal in buffer-separated concurrent flow lanes is considered subsidiary to debris removal in center medians and mainlanes, unless otherwise shown on the plans.

Debris removal required for work orders issued under Item 734, "Litter Removal," or Item 738, "Cleaning and Sweeping Highways," will be subsidiary to that Item unless otherwise shown on the plans.

Item 752
Tree and Brush Removal

1. DESCRIPTION

Remove and dispose of trees, brush, shrubs, and vines. Trim trees and shrubs. Remove stumps.

2. MATERIALS

Furnish commercially available pruning paint.

3. EQUIPMENT

Provide equipment necessary to complete the work.

4. WORK METHODS

Perform tree and brush removal and trimming from right of way line to right of way line or other widths and locations shown on the plans. Ensure trees, shrubs, and other landscape features that are to remain are not damaged. Dispose of debris within 48 hr. of cutting, off the right of way, in accordance with federal, state, and local regulations unless otherwise approved. When approved, chip debris and spread in a thin layer on the right of way.

4.1. **Tree Removal**. Remove trees of various diameters as shown on the plans, or as directed. Remove tree stumps to at least 12 in. below the surrounding terrain unless otherwise shown on the plans, or as directed. Backfill holes with acceptable material and compact flush with surrounding area.

4.2. **Tree Trimming**. Remove dead tree limbs. Remove tree limbs to the limits shown on the plans. Prune trees in accordance with Class IV National Arborist Association Pruning Standards for shade trees. Make cuts as close as possible to the trunk or parent limb without cutting into the branch collar or leaving a protruding stub. Remove suckers to the height of the lowest main branch.

When removing limbs 2 in. in diameter or larger:

- Undercut 1/3 way through the limb 8 to 12 in. from the main stem.
- Remove limb 4 to 6 in. outside the first cut.
- Remove stub with an even flush cut so that a trace (collar) protrudes approximately 1/2 in.
- Do not allow limb to fall free if it can damage other limbs or items.
- Treat exposed cuts on oak trees with wound dressing within 20 min. of the cut.

Disinfect tools with 70% methyl alcohol, benzalkonium chloride, chlorine solution, or other approved disinfectant when trimming oak trees and when shown on the plans before cutting, and sterilize/sanitize again before cutting another tree. Avoid pruning between February 15 and June 15, the period for maximum insect and fungal activity.

4.3. **Brush Removal**. Remove brush including, but not limited to, bushes, small trees, and vines growing within the right of way by cutting parallel to and within 1 in. of the ground and to the limits shown on the plans. Remove brush from under bridges, around culverts, and in channels to the limits shown on the plans.

4.4. **Channel Work**. Trim trees and remove brush to the limits shown on the plans, including areas under bridges.

4.5. **Stump Removal**. Remove tree stumps at least 12 in. below the surrounding terrain unless otherwise shown on the plans, or as directed. Backfill holes with acceptable material and compact flush with surrounding area.

5. MEASUREMENT

This Item will be measured as follows:

5.1. **Tree Removal**. By each tree of the diameter specified. The diameter will be measured 3 ft. above the ground. Trees less than 4 in. in diameter are considered brush. Trees with multiple trunks at the point of measurement will be measured separately and paid for according to the specified diameter. Removal of the stump is subidiary to Tree Removal.

5.2. **Tree Trimming and Brush Removal**. By the centerline mile of the dimension specified. “Centerline mile” is defined as the continuous measurement along the center of the right of way.

5.3. **Tree Trimming and Brush Removal for Channels**. By the acre.

5.4. **Stump Removal**. By each stump removed. This item is for stumps where others previously removed the tree.

6. PAYMENT

The work performed in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for “Tree Removal” of the diameter specified, “Tree Trimming” of the dimension specified, “Brush Removal,” “Tree Trimming and Brush Removal,” and “Stump Removal.” This price is full compensation for removal, trimming, disposal, equipment, traffic control, labor, and incidentals.

When not shown on the plans as a separate pay item, payment for tree trimming and brush removal in channels will be included in payment by the centerline mile. When shown on the plans as a separate pay item, tree trimming and brush removal in channels will be paid for at the unit price bid for “Tree Trimming and Brush Removal (Channels).”

The limits shown on the plans are the limits for pay purposes unless otherwise modified in accordance with Article 4.4., “Changes in the Work.”

Item 760
Cleaning and Reshaping Ditches

1. DESCRIPTION

Clean and reshape ditches.

2. WORK METHODS

Excavate and remove excess material from ditches and from around fixtures within the limits of the excavation or reshape by cleaning silt from the ditch and spreading on backslope as approved. Reshape ditches in conformance with the lines, grades, and typical cross-sections shown on the plans, or as directed. Dispose of excess material in accordance with applicable federal, state, and local regulations, or place on right of way, as directed. Maintain ditch drainage during cleaning and reshaping work.

3. MEASUREMENT

Measurement will be as follows:

3.1. **Foot**. By the foot, measured along the centerline of the ditch.

3.2. **Cubic Yard in Place**. By the cubic yard in its original position computed by the method of average end areas.

3.3. **Cubic Yard in Vehicle**. By the cubic yard in vehicles measured at the point of excavation.

4. PAYMENT

The work performed in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for “Ditch Reshaping (Foot),” “Ditch Cleaning and Reshaping (Cubic Yard in Place),” or “Ditch Cleaning and Reshaping (Cubic Yard in Vehicle).” This price is full compensation for excavation, disposal of removed materials, reshaping, equipment, labor, tools, and incidentals.

Item 780
Concrete Crack Repair

1. DESCRIPTION

Repair cracks in concrete members by epoxy injection, gravity filling, routing and sealing, or surface sealing.

2. MATERIALS

Provide materials in accordance with the Department's *Concrete Repair Manual*. Select a pre-approved material meeting the requirements of the applicable DMS when available.

3. WORK METHODS

Follow the procedures outlined in the Department's *Concrete Repair Manual*. Submit alternate procedures to the Engineer for approval before proceeding with repair work.

The manual includes the following categories of concrete crack repair:

- Pressure-Injected Epoxy,
- Gravity-Fed Sealant,
- Routing and Sealing, and
- Surface Sealing.

4. MEASUREMENT

This Item will be measured by the foot of exterior crack length, injected gallon, square footage for flood coats, or lump sum.

5. PAYMENT

The work performed and the materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Concrete Crack Repair" of the type specified. This price is full compensation for furnishing and installing all repair materials, equipment, labor, and incidentals.