SECTION 01 00 00 - TABLE OF CONTENTS

NOTE: The Texas Department of Transportation (TxDOT) Standard Specification Sections (2024 revisions) and Standard Details (most recent) listed in the Table of Contents, cross referenced in the TxDOT Specification Sections, and referenced in the Drawings and referenced in other technical specifications are included in the Contract Documents and incorporated in this Project Manuals by reference as if copied verbatim. Copies of the TxDOT Specification Sections and other cross referenced TxDOT requirements can be downloaded from TxDOT's website at the following link.

https://www.txdot.gov/business/resources/txdot-specifications/2024-standard-specifications.html

DIVISON 01 – GENERAL REQUIREMENTS

01 00 00 Table of Contents
01 00 07 Seals Page
01 00 15 List of Drawings
01 11 00 Summary of Work
01 29 01 Measurement and Basis for Payment
01 33 01 Submittal Register
01 57 00 Temporary Controls

TECHNICAL SPECIFICATIONS

02 52 50 Gravel Road Pavement
06 10 63 Exterior Rough Carpentry

TXDOT SPECIFICATIONS

TxDOT DMS-6200 Filter Fabric
TxDOT Item 104 Removing Concrete
TxDOT Item 110 Excavation
TxDOT Item 132 Embankment
TxDOT Item 150 Blading
TxDOT Item 160 Topsoil
TxDOT Item 164 Seeding for Erosion Control
TxDOT Item 169 Soil Retention Blanket
TxDOT Item 192 Landscape Planting
TxDOT Item 210 Rolling
TxDOT Item 247 Flexible Base
TxDOT Item 250 Geogrid Base Reinforcement
TxDOT Item 260 Lime Treatment (Road-Mixed)
TxDOT Item 275 Cement Treatment (Road-Mixed)
TxDOT Item 400 Excavation and Backfill for Structures
TxDOT Item 401 Flowable Backfill

TxDOT	Item 403	Temporary Special Shoring
TxDOT	Item 416	Drilled Shaft Foundation
TxDOT	Item 420	Concrete Substructures
TxDOT	Item 421	Hydraulic Cement Concrete
TxDOT	Item 422	Concrete Superstructures
TxDOT	Item 423	Retaining Walls
TxDOT	Item 432	Riprap
TxDOT	Item 440	Reinforcement for Concrete
TxDOT	Item 441	Steel Structures
TxDOT	Item 442	Metal for Structures
TxDOT	Item 447	Structural Bolting
TxDOT	Item 448	Structural Field Welding
TxDOT	Item 449	Anchor Bolts
TxDOT	Item 459	Gabions and Gabion Mattresses
TxDOT	Item 466	Headwall and Wingwalls
TxDOT	Item 496	Removing Structures
TxDOT	Item 506	Temporary Erosion, Sediment, and Environmental Controls
TxDOT	Item 752	Tree and Brush Removal

Special Specification

TxDOT	(SS) Item 4007	Pre-Engineered Steel Truss Bridge

APPENDIX

A	Geotechnical Engineering Report By Alpha Testing Dated 8/15/24 (UES Project No. 23-0722).
B	C0139-0007-01 Nails Creek Survey by Quiddity Dated 9/13/2023
C	C0139-0007-01 Yegua Creek Survey by Quiddity Dated 9/13/2023
D	Borrow Site: Bore Map and Bore Log, Dated July 14, 2025

END OF SECTION

SECTION 01 00 07 - SEALS PAGE

CONSULTANTS SEALS PAGE

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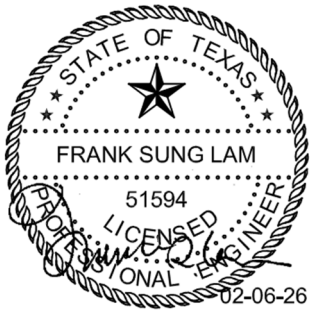
Registration No. F–2545
Expiration Date 12–31–2026
FLA PROJECT NUMBER: 2305



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INFRASTRUCTURE DIVISION

SECTION 01 00 15 – LIST OF DRAWINGS

ITEM	SHEET NO.	DESCRIPTION	REVISION	
			NO.	DATE
1	G-01	COVER SHEET	0	02/06/26
2	G-02	OVERALL SITE LOCATIONS	0	02/06/26
3	G-03	NAILS CREEK CONSTRUCTION SITE	0	02/06/26
4	G-04	YEGUA CREEK CONSTRUCTION SITE	0	02/06/26
5	G-05	ADDITIONAL CONTRACTOR LAYDOWN AREAS	0	02/06/26
6	G-06	SURVEY AND CONTROL - NAILS CREEK	0	02/06/26
7	G-07	SURVEY AND CONTROL - YEGUA CREEK CIVIL	0	02/06/26
8	C-01	GENERAL CIVIL NOTES	0	02/06/26
9	C-02	SWPPP PLANS NAILS & YEGUA CREEKS	0	02/06/26
10	C-03	SWPPP DETAILS	0	02/06/26
11	C-04	TREE PROTECTION DETAILS	0	02/06/26
12	C-05	DEMOLITION PLANS-NAILS CREEK	0	02/06/26
13	C-06	DEMOLITION PLANS-YEGUA CREEK	0	02/06/26
14	C-07	NAILS CREEK OVERALL VIEW	0	02/06/26
15	C-08	CIVIL PLAN & PROFILE - NAILS CREEK	0	02/06/26
16	C-09	NAILS CREEK BANK STABILIZATION PLAN	0	02/06/26
17	C-10	NAILS CREEK CROSS SECTION SHEET 1 OF 3	0	02/06/26
18	C-11	NAILS CREEK CROSS SECTION SHEET 2 OF 3	0	02/06/26
19	C-12	NAILS CREEK CROSS SECTION SHEET 3 OF 3	0	02/06/26
20	C-13	YEGUA CREEK OVERALL VIEW	0	02/06/26
21	C-14	CIVIL PLAN & PROFILE - YEGUA CREEK	0	02/06/26
22	C-15	YEGUA CREEK BANK STABILIZATION PLAN	0	02/06/26
23	C-16	YEGUA CREEK CROSS SECTION SHEET 1 OF 3	0	02/06/26
24	C-17	YEGUA CREEK CROSS SECTION SHEET 2 OF 3	0	02/06/26
25	C-18	YEGUA CREEK CROSS SECTION SHEET 3 OF 3	0	02/06/26
26	C-19	CREEK STABILIZATION DETAILS	0	02/06/26
27	C-20	BRIDGE APPROACH DETAILS SHEET 1 OF 2	0	02/06/26
28	C-21	BRIDGE APPROACH DETAILS SHEET 2 OF 2	0	02/06/26
29	C-22	BRIGE APPROACH GABION WALL PROFILES	0	02/06/26
30	C-23	GABION BASKET DETAILS	0	02/06/26
31	C-24	TXDOT SIGN DETAILS	0	02/06/26
32	C-25	BORROW SITE - EXISTING SITE PLAN	0	02/06/26
33	C-26	BORROW SITE - SWPP PLAN	0	02/06/26
34	C-27	BORROW SITE - PROPOSED PLAN & PROFILE SHEET 1 OF 4	0	02/06/26
35	C-28	BORROW SITE - PROPOSED PLAN & PROFILE SHEET 2 OF 4	0	02/06/26
36	C-29	BORROW SITE - PROPOSED PLAN & PROFILE SHEET 3 OF 4	0	02/06/26
37	C-30	BORROW SITE - PROPOSED PLAN & PROFILE SHEET 4 OF 4	0	02/06/26
38	C-31	BORROW SITE - PROPOSED CROSS SECTIONS	0	02/06/26
39	S1	STRUCTURAL NAILS CREEK PLAN & PROFILE	0	02/06/26

40	S2	STRUCTURAL YEGUA CREEK PLAN & PROFILE	0	02/06/26
41	S3	STRUCTURAL BRIDGE ABUTMENT DETAILS	0	02/06/26
42	S4	STRUCTURAL ABUTMENT PLAN & BRIDGE SECTIONS	0	02/06/26
43	S5	STRUCTURAL NOTES	0	02/06/26

END OF SECTION

SECTION 011100

SUMMARY OF WORK

1.00 GENERAL

1.01 WORK INCLUDED

A. Construct Work as described in the Contract Documents.

1. Provide the materials, equipment, labor, supplies, and incidentals required for the proposed Lake Somerville Trailway Trail Bridge Replacements project.
2. The Contract Documents do not indicate or describe all of the Work required to complete the Project. Additional details required for the correct installation of selected products are to be provided by the Contractor and coordinated with the Owner and Engineer.

1.02 DESCRIPTION OF WORK

A. Work at Nails Creek and Yegua Creek is described in general as:

1. Provide Storm Water Pollution Protection Plan (SWPPP) and devices as shown in the drawings (ex., silt fencing).
2. Protection of existing trees, creek, roads, trails, facilities, and infrastructure and maintaining safe and unobstructed access for park guests and staff.
3. Preservation of adjacent wetlands and vegetation.
4. Clearing and grubbing, including brush and tree debris removal from within the creeks.
5. Demolition and removal of remaining bridge structures, and the removal of specific trees as shown in the drawings.
6. Provide cast-in-place reinforced concrete drilled piers, abutments, and wingwall systems for bridges.
7. Provide pre-engineered and premanufactured ADA-compliant steel truss bridges with reinforced concrete bridge decks.
8. Provide gravel bridge approaches with gabion basket retaining wall systems.
9. Restore the eroded creek banks damaged by flood events to the limits shown in the drawings.
10. Provide rock riprap protection around bridge abutments and wing wall systems.
11. Restore surrounding site.

B. Work at Channel Berm Site is described in general as:

1. Protection of existing trees, channel, trails and culverts.
2. Excavate the berm to the profile shown in the plans.
3. Remove all vegetation and other unsuitable materials from the excavated soils for reuse as fill at the bridge replacement sites.

1.03 SUBSTANTIAL COMPLETION

A. All Work must be completed and corrected to achieve Substantial Completion.

1.04 TEMPORARY FACILITIES AND UTILITIES

A. Contractor shall provide their own temporary facilities and utilities (ex., power, water, phone, porta-potties, trailer, etc.), including but not limited to all labor, materials, equipment, services, meter connection fees, utility bills, permits, etc. necessary to install, maintain, remove, and restore temporary facilities and utilities.

1.05 USE PRIOR TO FINAL COMPLETION

A. Owner has the right to use or operate any portion of the Project that is ready for use after notifying the Contractor of its intent to do so.

B. Conduct operations to insure the least inconvenience to the Owner and general public.

2.00 PRODUCTS (NOT USED)

3.00 EXECUTION (NOT USED)

END OF SECTION

SECTION 01 29 01

MEASUREMENT AND BASIS FOR PAYMENT

1.00 GENERAL

1.01 MEASUREMENT AND BASIS FOR PAYMENTS - GENERAL

A. Disregard the measurement and payment sections of the TxDOT specifications. Measurement and payment of Work covered by TxDOT specifications shall be as indicated in this section.

1.02 MEASUREMENT AND BASIS FOR PAYMENTS ON LUMP SUM ITEMS

A. Include all cost for completing the Work in accordance with the Contract Documents for lump sum items. Include all direct cost for the Work associated with that lump sum item and a proportionate amount for the indirect costs as described in the UNIFORM GENERAL CONDITIONS and the Contract Documents for each lump sum item. Include all costs not specifically set forth but required to provide a complete and functional system in the lump sum price.

B. Measurement for progress payments will be made on the basis of the earned value for each item shown as a percentage of the cost for the lump sum item as described in the UNIFORM GENERAL CONDITIONS and the Contract Documents. Payment at Final Completion will be equal to the total lump sum amount for that item.

C. Within 30 days after notice to proceed and prior to submitting the first monthly pay application, Contractor shall submit for review and approval a proposed schedule of value (SOV) breakout for both based bid and alternate bid pay items that will be used for determining interim monthly payments.

1.03 MEASUREMENT AND BASIS FOR PAYMENT FOR BASE BID ITEMS

A. **BASE PROPOSAL 1** - Base proposal will be a Lump Sum (LS) Price for both Nails and Yegua Creek and shall include but not limited to:

1. Mobilization & Demobilization

   a. A maximum of 5% of the base bid price to be used for mobilization and demobilization

   b. This includes transportation and set up for equipment; erection of field offices, sheds, storage facilities as needed; Salaries for preparation of documents required before the first Application for Payment, and Salaries for personnel assigned to the project.

2. Bond and Insurance (maximum of 2% of the base bid price to be used for the purchase of bonds and insurance)

3. Traffic Control Plan & Traffic Control Items

   a. This includes furnishing, installing, moving, replacing, and maintaining all temporary traffic controls such as barricades, signs, barriers, cones, temporary detours, flaggers, temporary drainage pipes and structures, etc.

4. SWPPP Plan & SWPPP Items
    a. This includes furnishing, installation, and maintenance of silt fencing, filter Socks, etc as indicated in the drawings.
5. Stabilized Construction Entrance (Installation, Maintaining , and Removal)
6. Laydown Site Preparation
    a. Including removal of vegetation and debris from the site, and installing security/perimeter fences if necessary.
7. Repairing existing trail for temporary construction access
    a. This includes demolition of the existing trail, the reinstallation of the trail, and any treated materials, culverts, etc.

B. **BASE PROPOSAL 2** - Base proposal will be a Lump Sum (LS) Price for Nails Creek and shall include but not limited to:

1. Demolition
    a. This includes the demolition and removal of existing abutments, wingwalls, timber piles, tree & brush, debris, approaches, trees, etc as indicated in the drawings.
2. Tree Protection & Planting
    a. Tree protection and planting to follow what is indicated in the drawings.
    b. The trees being planted are required to be pecan trees native to the area, with a minimum of 2 years of age and a tree caliper of 2-3 inches. Contractor will be required to provide documentation of the proposed trees for review by the Engineer and OAR.
3. Bank Restoration & Stabilization
    a. This includes backfill the creek banks using the excavated material from the borrow site, the preparation/installation of the soil retention blankets and filter fabric, crushed stone backfill, and rip rap as indicated in the Drawings and Specifications.
4. Bridge Approaches
    a. This includes the preparation/installation of the gabion baskets & mattress, filter fabric, and geogrid as indicated in the drawings
    b. The preparation, compaction, and treatment of the lime treated subgrade, and base material as indicated in the drawings
    c. Backfilling within the bridge approaches, and filling the site and embankment as shown in the drawings using the excavated material from the borrow site
    d. Preparation and installation of rub rail structures
5. Site Restoration

a. This includes tilling, top-soiling, planting, seeding, watering, maintaining vegetation, installation of the trail sign (submit for review by the Engineer and OAR)

6. Pre-engineered Steel Bridge & Concrete Structure

a. This includes drilled shaft foundations (24in & 30in diameter); Concrete Abutments (Class S, 4000 Psi), Retaining Walls (Class C, 3600 Psi), Bridge Deck (Class C, 4600 Psi)

b. Furnishing and Erection of the Pre-Engineered Steel Bridge, Handrail/Rub Rail System, and all miscellaneous items such as Anchor Bolts, Bearing Pads, Cover Plates, etc.

c. Select Fill and Backfill (CLSM)

d. Temporary Measures To Access Opposite Side Of Creek (Prep, Maintain & Restore)

C. **BASE PROPOSAL 3** - Base proposal will be a Lump Sum (LS) Price for Yegua Creek and shall include but not limited to:

1. Demolition

a. This includes the demolition and removal of existing abutments, wingwalls, timber piles, tree & brush, debris, approaches, trees, etc as indicated in the drawings.

2. Tree Protection

a. Tree protection and planting to follow what is indicated in the drawings.

3. Bank Restoration & Stabilization

a. This includes backfill the creek banks using the excavated material from the borrow site, the preparation/installation of the soil retention blankets and filter fabric, crushed stone backfill, and rip rap as indicated in the Drawings and Specifications.

4. Bridge Approaches

a. This includes the preparation/installation of the gabion baskets & mattress, filter fabric, and geogrid as indicated in the drawings

b. The preparation, compaction, and treatment of the lime treated subgrade, and base material as indicated in the drawings

c. Backfilling within the bridge approaches, and filling the site and embankment as shown in the drawings using the excavated material from the borrow site

d. Preparation and installation of rub rail structures

5. Site Restoration

a. This includes tilling, top-soiling, planting, seeding, watering, maintaining vegetation, installation of the trail sign (submit for review by the Engineer and OAR)

6. Pre-engineered Steel Bridge & Concrete Structure
    a. This includes drilled shaft foundations (24in & 30in diameter); Concrete Abutments (Class S, 4000 Psi), Retaining Walls (Class C, 3600 Psi), Bridge Deck (Class C, 4600 Psi)
    b. Furnishing and Erection of the Pre-Engineered Steel Bridge, Handrail/Rub Rail System, and all miscellaneous items such as Anchor Bolts, Bearing Pads, Cover Plates, etc.
    c. Select Fill and Backfill (CLSM)
    d. Temporary Measures To Access Opposite Side Of Creek (Prep, Maintain & Restore)

D. **BASE PROPOSAL 4** - Base proposal will be a Lump Sum (LS) Price for the excavation at the borrow site and shall include but not limited to:
1. SWPPP Plan & SWPPP Items
    a. This includes furnishing, installation, and maintenance of silt fencing, filter Socks, etc as indicated in the drawings.
2. Preparation of an excavated material haul/transportation plan
3. Stabilized Construction Entrance (Installation, Maintaining , and Removal)
4. Demolition
    a. This includes the site clear & grubbing, removal of brush & debris, mowing of grass at the site.
5. Excavation and Removal/Disposal Vegetation
    a. Excavate to the limits shown in the drawings, remove all vegetation and debris from the excavated soils for reuse at the project sites
    b. Perform surveys and earthwork volume reports that will be used to measure the total volume removed from the site. Surveys shall be by a Registered Professional Land Surveyor (RPLS) registered in Texas acceptable to the EOR and TPWD. Surveys and volume reports shall be provided to the EOR for review.
    c. Contractor shall excavate no more than 3,047 CY. Contractor shall notify EOR and TPWD if further excavation for fill material is required for the project sites to gain approval.
6. Haul/Transport Excavated Backfill Material To Project Sites

2.00 PRODUCTS (NOT USED)

3.00 EXECUTION (NOT USED)

END OF SECTION

Submittal Import Template

Project Number:	1211815					
CSI Specification Section Code:	CSI Specification Description: Character limit 100	Category:	Sub Section:	Critical Path?:	Date Due Submit For Review:	Date Due Review Complete
Uniform General Conditions	Proposed baseline CPM schedule	Other				
Uniform General Conditions	Monthy CPM progress schedules	Other				
Uniform General Conditions	Submittal Schedule/Register	Other				
Uniform General Conditions	Asbuilt drawings	Record Documents				
Uniform General Conditions	Pre-construction photographs	Other				
01 57 00	Plan for maintaining creek flow during construction. Includes drawings, details, data, sequencing plan, etc.	Other				
02 52 50	Submit source of proposed aggregate material, sieve analysis, and test data reports for aggregate material	Other				
06 10 63	Submit Product Data, Shop Drawings, and Certificates	Shop Drawing				
Txdot item 132	Submit Product data(Material, LL, PI, Linear Shrinkage), Source name & location	Other	Note 1			
Txdot item 160	Submit Source name & location; pH if additional topsoil is needed.	Other	Note 1			
Txdot item 164	Submit Seed mix(s); species, fertilizer; cellulose fiber mulch; tacking agent	Other	Note 1			
Txdot item 166	Submit Product Data	Other				
Txdot item 169	Submit product data; Shop Drawings	Other	Note 1			
Txdot item 192	Submit plan layout; Shop Drawings	Other				
Txdot item 247	Submit Material source, Product Data, Five (5) most recent material gradation test reports	Other	Note 1			
Txdot item 400	Material source names and locations; mix design; material gradation report; certifications	Other	Note 1			
Txdot item 401	Material source names and locations; mix design; material gradation report and PI,	Other	Note 1			
Txdot item 403	Submit shoring plan including sequence of construction, details, and design calculations bearing the seal of a licensed professional engineer before constructing the shoring.	Other	Note 1			
Txdot item 416,420,421,422	Material source name and location; mix design; material gradation reports; certifications; "Buy America" documentation Form 1818; Mill test reports, certifications	Other	Note 1			
Txdot item 423	Material source name and location; plan layout; mix design; material gradation reports; certifications; "Buy America" documentation Form 1818; Mill test reports, certifications	Other	Note 1			
Txdot item 432	Material source name and location; mix design; material gradation reports; certifications; "Buy America" documentation Form 1818; Mill test reports, certifications, coating reports	Other	Note 1			
Txdot item 440	Submit product data; Shop Drawings	Shop Drawing				
Txdot item 441,447,449	Submit product data; Shop Drawings	Shop Drawing				
Txdot item 459	Submit product data; Shop Drawings	Shop Drawing				
Txdot item 4007	Submit product data; Shop Drawings	Shop Drawing				

SECTION 01 57 00

TEMPORARY CONTROLS

1.00 GENERAL

1.01 WORK INCLUDED

A. Provide labor, materials, equipment, and incidentals necessary to construct temporary controls to provide and maintain control over environmental conditions at the site. Remove temporary controls when no longer needed.

B. Construct temporary impounding works, channels, diversions, furnishing and operation of pumps, installing piping and fittings, and other construction for control of conditions at the site. Remove temporary controls at the end of the Project.

C. Comply with SWPPP requirements indicated on the drawings and comply with applicable requirements in TxDOT Item 506 - Temporary Erosion, Sedimentation, and Environmental Controls.

D. Provide and maintain Best Management Practices (BMP) as required to prevent sediment and other pollutants from entering any stormwater system including creeks and wetlands. Remove BMPs when no longer required to prevent stormwater pollution.

E. Contractor shall modify the BMP systems as required to effectively control erosion and sediment.

F. Return any property disturbed by construction activities to either specified conditions or pre-construction conditions as set forth in the Contract Documents. Provide an overall erosion and sedimentation control system that will protect all undisturbed areas and soil stockpiles/spoil areas. Permanently stabilize exposed soil and fill it as soon as practical during the Work.

G. Provide temporary traffic control devices, barricades, and signage, as necessary, to prevent park visitors from entering construction areas and to direct park traffic, around, though, or away from construction activities.

1.02 RELATED DOCUMENTS

A. TxDOT Item 506 - Temporary Erosion, Sedimentation, and Environmental Controls.

B. Drawings – Typical SWPPP details.

1.03 QUALITY ASSURANCE

A. Construct and maintain temporary controls with adequate workmanship using durable materials to provide effective environmental management systems meeting the requirements of the Contract Documents and Laws and Regulations. Use materials that require minimal maintenance to prevent disruption of construction activities while providing adequate protection of the environment.

B. Periodically inspect systems to determine that they are meeting the requirements of the Contract Documents.

1.04 SUBMITTALS

A. Submit product data and details of proposed BMPs (ex., silt fencing, stabilized construction entrances, etc.).

B. Provide copies of applicable notices, records, reports, permits, etc. required by the Contract Documents and Laws and Regulations.

C. Submit proposed plan for temporarily diverting creek flow while performing work on creek banks (ex., cast-in-place reinforced concrete bridge abutments, creek restoration, rock riprap, etc.). Proposed plan shall include shop drawings, details, data and sequencing plan for proposed temporary diversion structures and temporary pumping system. Proposed plan shall include proposed plan for removing all temporary diversion structures and temporary pumping systems and restoring the site prior to substantial completion. Proposed plan shall also include proposed emergency plan for temporarily removing temporary structures/pumps and securing the site prior to forecasted flooding and major rain events. Proposed plan shall be signed and sealed by a professional engineer registered in Texas.

1.05 POLLUTION CONTROL

A. Prevent the contamination of soil, water, or atmosphere by the discharge of noxious substances from construction operations. Provide adequate measures to prevent the creation of noxious air-borne pollutants. Prevent dispersal of pollutants into the atmosphere. Do not dump or otherwise discharge noxious or harmful fluids into drains or sewers, nor allow noxious liquids to contaminate public waterways in any manner.

B. Provide equipment and personnel and perform emergency measures necessary to contain any spillage.

1. Contain chemicals in protective areas and do not dump on soil. Dispose of such materials at off-site locations in an acceptable manner.

2. Excavate contaminated soil and dispose at an off-site location if contamination of the soil does occur. Fill resulting excavations with suitable backfill and compact to the density of the surrounding undisturbed soil.

3. Provide documentation to the Owner which states the nature and strength of the contaminant, method of disposal, and the location of the disposal site.

4. Comply with Laws and Regulations regarding the disposal of pollutants.

C. Groundwater or run-off water which has come into contact with noxious chemicals, sludge, or sludge-contaminated soil is considered contaminated. Contaminated water must not be allowed to enter streams or water courses, leave the Site in a non-contained form, or enter non-contaminated areas of the Site.

1. Pump contaminated water to portable tanks. Pump contaminated water to holding ponds constructed by the Contractor for this purpose if approved by the Owner.

2. Construct temporary earthen dikes or take other precautions and measures as required to contain the contaminated water and pump to a designated storage area.

3. Wash any equipment used for handling contaminated water or soil within contaminated areas three times with uncontaminated water prior to using such equipment in an uncontaminated area. Dispose of wash water used to wash such equipment as contaminated water.

1.06 EARTH CONTROL

A. Remove excess soil, spoil materials, and other earth not required for backfill at the time of generation. Control stockpiled materials to eliminate interference with Contractor and Owner's operations.

B. Dispose of excess earth off the Site. Provide written approval from the property owner for soils deposited on private property. Obtain approval of the Owner if this disposal impacts the use of Site or other easements.

1.07 MANAGEMENT OF WATER

A. Manage water resulting from creek flow, rains or ground water at the Site. Maintain trenches and excavations free of water.

B. Lower/divert the creek water level to maintain excavations and work area free of water. Contractor's plan shall maintain creek flow by partially diverting creek flow with temporary structures and with temporary by-pass pumping systems.

C. Lower the water table in the construction area by acceptable means if necessary to maintain a dry and workable condition at all times. Provide drains, sumps, casings, well points, and other water control devices as necessary to remove excess water.

D. Provide continuous operation of water management actions. Maintain standby equipment to provide proper and continuous operation for water management.

E. Ensure that water drainage does not damage adjacent property. Divert water into the same natural watercourse in which its headwaters are located, or other natural stream or waterway as approved by the Owner. Assume responsibility for the discharge of water from the Site.

F. Remove the temporary construction and restore the Site in a manner acceptable to the Owner and to match surrounding material at the conclusion of the Work.

1.08 DEWATERING

A. This item is considered subsidiary for all dewatering methods where dewatering is needed to keep the excavation dry.

B. Storm water that enters an excavation can be pumped out as long as care is taken to minimize solids and mud entering the pump suction and flow is pumped to a location that allows for sheet flow prior to entering a storm water drainage ditch or storm water inlet.

C. An alternative to sheet flow is to pump storm water to an area where ponding occurs naturally without leaving the designated work area or by a manmade berm(s) prior to entering the storm water system. Sheet flow and ponding is to allow solids screening and/or settling prior to entering a storm water conduit or inlet.

D. Storm water or groundwater shall not be discharged to private property without permission. It is the intent that Contractor discharges groundwater primarily into the existing storm water system, provided that the quality of groundwater is equal to or better than the receiving stream or receiving body of water.

E. Testing of groundwater quality is to be performed by the Contractor, at the Contractors expense, prior to commencing discharge and shall be retested by the Contractor, at the Contractor's expense, a minimum of once a week. Tests will also be performed as each new area of construction is started.

2.00 PRODUCTS

2.01 MATERIALS

A. Provide materials as indicated on the drawings, this section and Item 506.

3.00 EXECUTION

3.01 CONSTRUCTING, MAINTAINING AND REMOVING TEMPORARY CONTROLS

A. Construct temporary controls in accordance with the drawings, this section, Item 506 and applicable Laws and Regulations.

B. Maintain controls in accordance with regulatory requirements where applicable, or in accordance with the requirements of the Contract Documents.

C. Remove temporary controls when no longer required, but before the Project is complete. Correct any damage or pollution that occurs as the result of removing controls while they are still required.

END OF SECTION

SECTION 02 52 50
GRAVEL ROAD PAVEMENT

1. SUBMITTALS
   a. Submit the source of the proposed aggregate material.
   b. Submit sieve analysis and test data reports for proposed aggregate material.

2. MATERIALS
   a. The aggregate material shall be free from vegetable matter and other deleterious substances.
      1) Provide crushed limestone granular base course meeting all the requirements of TXDOT item 247, type a, grade 1-2, including triaxial strength.
      2) The gravel road surfacing shall meet the following requirements.
         a) Plasticity Index: When tested in accordance with ASTMD 4318, the plasticity index shall be within 3 to 10.
         b) Liquid Limit: When tested in accordance with ASTMD 4318, the liquid limit shall not be more than 25.
         c) Lime Stabilization shall be performed in accordance with TxDOT Item 260 at an application rate of 36 lbs/SY to an application depth of 8 inches.
         d) The gravel road surfacing shall be placed in 8-inch-thick maximum lifts and compacted to at least 95% of the maximum dry density as determined by ASTM D698 at a moisture content ranging from ±2% of the optimum moisture content.

3. PREPARATION
   a. The subgrade and flex base surface areas to be surfaced shall be compacted as specified to the lines and grades shown on the drawings (including geotextile fabric) and shall be tested and inspected by the Owner's independent testing laboratory prior to placing the gravel road surfacing.

   b. All prepared subgrades shall be proof-rolled prior to placement of geotextile fabric and crushed limestone granular base course. Proof rolling should be performed using a loaded tandem-axle dump truck weighing at least 25 tons. Visually unstable areas and unstable areas identified by proof rolling shall be reworked; moisture conditioned, and properly compacted to the recommendations in the Compaction Requirements of the Geotechnical Report.

4. PLACEMENT
   a. The aggregate shall be deposited, spread, processed, and compacted on the prepared subgrade to the required thickness as shown on the drawings. In the event segregation occurs, the material shall be bladed until the various sizes of aggregate are uniformly and satisfactorily blended. After being spread, the material shall be watered, mixed, shaped to the required section, and compacted as indicated in this specification. The completed course shall be smooth, true to grade and cross-section, and free from ruts, humps, depressions, and irregularities.

END OF SECTION

SECTION 061063
EXTERIOR ROUGH CARPENTRY

1.00 GENERAL

1.01 SECTION INCLUDES

A. Wood boardwalks and Ramps.

1.02 DEFINITIONS

A. Boards: Lumber of less than 2 inches nominal in thickness and 2 inches nominal or greater in width.

B. Dimension Lumber: Lumber of 2 inches nominal or greater but less than 5 inches nominal in least dimension.

C. Timber: Lumber of 5 inches nominal or greater in least dimension.

D. Lumber grading agencies, and the abbreviations used to reference them, include the following:

1. NeLMA: Northeastern Lumber Manufacturers' Association.
2. NLGA: National Lumber Grades Authority.
3. SPIB: The Southern Pine Inspection Bureau.
4. WCLIB: West Coast Lumber Inspection Bureau.
5. WWPA: Western Wood Products Association.

1.03 SUBMITTALS

A. Product Data: For preservative-treated wood products. Include chemical treatment manufacturer's written instructions for handling, storing, installing, and finishing treated material.

B. Shop Drawings: Contractor shall submit detailed shop drawings and calculations for the handrails signed and sealed by a professional structural engineer registered to practice in Texas. Contractor's structural engineer shall design all structures in accordance with ADA and TAS accessibility requirements and in accordance with the design criteria and design loads indicated in the structural general notes and as indicated in the drawings and specifications. Detailed shop drawings shall be submitted for review and acceptance and shall contain the following for each structure.

1. Foundation pile plan, including proposed installation method
2. Elevations and sections
3. Connection details
4. Species, size and grade of lumber and timbers
5. Calculations including load and code design information

C. Certificates:

1. For preservative-treated wood products. Indicate type of preservative used and net amount of preservative retained.

2. Certificates of Inspection: Issued by lumber grading agency for exposed wood products not marked with grade stamp.

D. Submit product data and certifications for each size and type.

1. Include data for wood-preservative treatment from chemical treatment manufacturer and certification by treating plant that treated materials comply with requirements. Indicate type of preservative used and net amount of preservative retained.

2. For products receiving a waterborne treatment, include statement that moisture content of treated materials was reduced to levels specified before shipment to Project site.

1.04 DELIVERY, STORAGE, AND HANDLING

A. Store materials under cover and protected from weather and contact with damp or wet surfaces. Stack lumber flat with spacers between each bundle to provide air circulation. Provide for air circulation around stacks and under coverings.

2.00 PRODUCTS

2.01 LUMBER GENERAL

A. Comply with DOC PS 20 and with grading rules of lumber grading agencies certified by ALSC's Board of Review as applicable. If no grading agency is indicated, comply with the applicable rules of any rules-writing agency certified by ALSC's Board of Review.

1. Factory mark each item with grade stamp of grading agency.

2. For items that are exposed to view in the completed Work, mark grade stamp on end or back of each piece or omit grade stamp and provide certificates of grade compliance issued by grading agency.

B. Maximum Moisture Content:

1. Boards: 19 percent.

2. Dimension Lumber: 15 percent for 2-inch nominal thickness or less; no limit for more than 2-inch nominal thickness.

3. Timber. No limit.

2.02 LUMBER

A. Hand select wood for freedom from characteristics, on exposed surfaces and edges, that might cause injury or harm to the public from touching the surfaces and edges, including decay, honeycomb, knot holes, shake, splits, splinters, torn grain, and wane.

B. Southern pine (SPIB) No. 2 grade.

2.03 POSTS

A. Dimension Lumber Posts: Minimum 4”x4” nominal.

B. Timber Posts: Minimum 6”x6” nominal.

2.04 PRESERVATIVE TREATMENT

A. Pressure treat boards and dimension lumber with waterborne preservative according to AWPA U1; Use Category UC3b for exterior construction not in contact with the ground, and Use Category UC4a for items in contact with the ground.

B. Pressure treat with waterborne preservative according to AWPA U1; Use Category UC4a. Treatment with CCA shall include post-treatment fixation process.

2.05 FASTENERS

A. General: Provide fasteners of size and type indicated, acceptable to authorities having jurisdiction, and that comply with requirements specified in this article for material and manufacture. Provide nails or screws, in sufficient length, to penetrate not less than into wood substrate.

1. Use fasteners with hot-dip zinc coating complying with ASTM A153/A153M or ASTM F2329 unless otherwise indicated.

2. For pressure-preservative-treated wood, use stainless steel fasteners.

B. Nails: ASTM F1667.

C. Power-Driven Fasteners: ICC-ES AC70.

D. Wood Screws and Lag Screws: ASME B18.2.1, ASME B18.6.1, or ICC-ES AC233.

E. Carbon-Steel Bolts: ASTM A307 with ASTM A563 hex nuts and, where indicated, flat washers all hot-dip zinc coated.

F. Stainless Steel Bolts: ASTM F593, Alloy Group 1 or 2; with ASTM F594, Alloy Group 1 or 2 hex nuts and, where indicated, flat washers.

G. Post installed Anchors: Stainless steel, anchors with capability to sustain, without failure, a load equal to 6 times the load imposed when installed in unit masonry assemblies and equal to 4 times the load imposed when installed in concrete as determined by testing according to ASTM E488.

1. Stainless steel bolts and nuts complying with ASTM F593 and ASTM F594, Alloy Group 1 or 2.

3.00 EXECUTION

3.01 INSTALLATION

A. Set work to required levels and lines, with members plumb, true to line, cut, and fitted. Fit work to other construction; scribe and cope as needed for accurate fit.

B. Framing Standard: Comply with AF&PA WCD1 unless otherwise indicated.

C. Install metal framing anchors to comply with manufacturer's written instructions.

D. Do not splice structural members between supports unless otherwise indicated.

E. Provide blocking and framing as indicated and as required to support facing materials, fixtures, specialty items, and trim.

F. Sort and select lumber so that natural characteristics do not interfere with installation or with fastening other materials to lumber. Do not use materials with defects that interfere

with function of members or pieces that are too small to use with minimum number of joints or optimum joint arrangement.

G. Make tight connections between members. Install fasteners without splitting wood.

4.00 MEASURMENT AND PAYMENT

Measurement and payment will in accordance with the contract documents and bid form items related to this section

END OF SECTION

DMS-6200
Filter Fabric

Effective Date: October 2025

1. DESCRIPTION

This Specification governs the sampling, testing, and material requirements of filter fabrics.

2. UNITS OF MEASUREMENTS

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

3. DEFINITIONS

3.1. **Filter Fabric**. A special fabric usually used in drainage applications to allow water flow without clogging or binding by soil particles.

3.1.1. **Type 1**. Type 1 is a standard weight fabric for retaining walls and soil separation.

3.1.2. **Type 2**. Type 2 is a high-strength fabric for rock riprap or other severe use.

4. MATERIAL PRODUCER LIST

The Materials and Tests Division (MTD) maintains the Material Producer List (MPL) of all materials in accordance with the requirements of this Specification. Materials appearing on the MPL entitled "Silt Fence, Filter Fabric, and Fabric Underseal" require no further sampling and testing before use, unless deemed necessary by the project Engineer or MTD.

DISREGARD

~~The MPLs associated with this DMS include notations that identify products or materials that are pre-certified to comply with Buy America, Gold Star certification. Submit the Department's "Buy America Certification" Form 2812 found on TxDOT.gov for Gold Star certification. Provide additional form or documentation upon Department request. Submit a new form if material or product Build America, Buy America (BABA) compliance status changes. BABA compliance status change means anytime the product's Buy America status, as represented on the MPL, changes. The Department maintains authority for establishing BABA material classifications (iron or steel, manufactured product, construction material, or excluded material).~~

5. SAMPLING AND TESTING

Sample in accordance with Tex-735-I. Perform testing in accordance with the test methods listed in Table 1.

Table 1
Filter Fabric Requirements

Physical Properties	Test Method	Type 1	Type 2
Fabric Weight, on an ambient temperature air-dried, tension-free	Tex-616-J	136.0 (4) Min	203.0 (6) Min

sample, g per square meter (oz. per square yard)			
Physical Properties	**Test Method**	**Type 1**	**Type 2**
Permittivity, 1 per second	ASTM D4491	1.0 Min	0.5 Min
Tensile Strength, N (lb.)	ASTM D4632	445 (100) Min	890 (200) Min
Apparent Opening Size	ASTM D4751	70–100	80–120
Elongation at Yield, %	ASTM D4632	20–100	20–100
Trapezoidal Tear, N (lb.)	ASTM D4533	156 (35) Min	334 (75) Min

6. BIDDERS' AND SUPPLIERS' REQUIREMENTS

The Department will only purchase or allow on projects those products listed by producer and product code or designation shown on the MPL.

Use of pre-qualified product does not relieve the Contractor of the responsibility to provide product that meets this Specification. The Department may inspect or test material at any time and reject any material that does not meet the Specifications.

7. PRE-QUALIFICATION PROCEDURE

Refer to DMS-6320, "Quality Monitoring Program for Temporary Sediment Control Fence Fabric, Filter Fabric, and Fabric Underseal," for further details on qualifying for the Quality Monitoring Program and obtaining a place on the MPL.

8. MATERIAL REQUIREMENTS

8.1. **General Requirements**. Both types of filter fabric have the following qualities.

- The fabric consists exclusively of manmade thermoplastic fibers, is a non-woven geotextile fabric, and forms a mat of uniform quality
- Fabric fibers are continuous and random throughout the fabric
- The fabric is mildew resistant and rot-proof, and it is satisfactory for use in a wet soil and aggregate environment.

8.2. **Physical Requirements**. The fabric must be in accordance with the requirements listed in Table 1 when tested in conformance with the test methods specified.

9. PACKAGING

Provide fabric in the length and width specified on the plans, specified in the purchase order awarded by the State, or as approved.

Wind fabric onto suitable cylindrical forms or cores to aid in handling and unrolling.

Package fabric individually in a suitable container to protect the geotextile from damage due to ultraviolet light and moisture during normal storage and handling.

10. IDENTIFICATION

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

- Unique roll number, serially designated

- Lot number or control numbers, if any
- Name of fabric producer
- Style or catalog designation of the fabric, if any
- Roll width in meters (inches)
- Roll length in meters (yards)

11. ARCHIVED VERSIONS

Archived versions are available.

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 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 150
Blading

1. DESCRIPTION

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

2. EQUIPMENT

Use a dual or four-wheel drive power maintainer equipped with pneumatic tires, a blade at least 12 ft. long, and a wheelbase of no less than 16 ft. when work is measured and paid for 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.

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 "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 will not be measured or 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 160
Topsoil

1. DESCRIPTION

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

2. MATERIALS

Use easily cultivated, fertile topsoil that is free from objectionable material and resists erosion. Obtain topsoil from the right of way at sites of proposed excavation or embankment when specified on the plans, or as directed. Secure additional topsoil, if necessary, from approved sources outside the right of way in accordance with the requirements of Article 7.7., "Preservation of Cultural and Natural Resources and the Environment." Ensure that the topsoil obtained from sites outside the right of way has a pH of 5.5 to 8.5, per Tex-128-E. Topsoil is subject to testing by the Engineer. Furnish water in accordance with Article 168.2., "Materials."

3. CONSTRUCTION

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

4. MEASUREMENT

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

5. PAYMENT

The work performed and the materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Furnishing and Placing Topsoil" of the depth specified on the plans (except for measurement by the cubic yard). This price is full compensation for securing necessary sources and royalties; furnishing topsoil; excavation, loading, hauling, stockpiling and placing; watering; rolling; and equipment, labor, materials, tools, and incidentals. Limits of excavation and embankment for payment are shown in Figure 1.

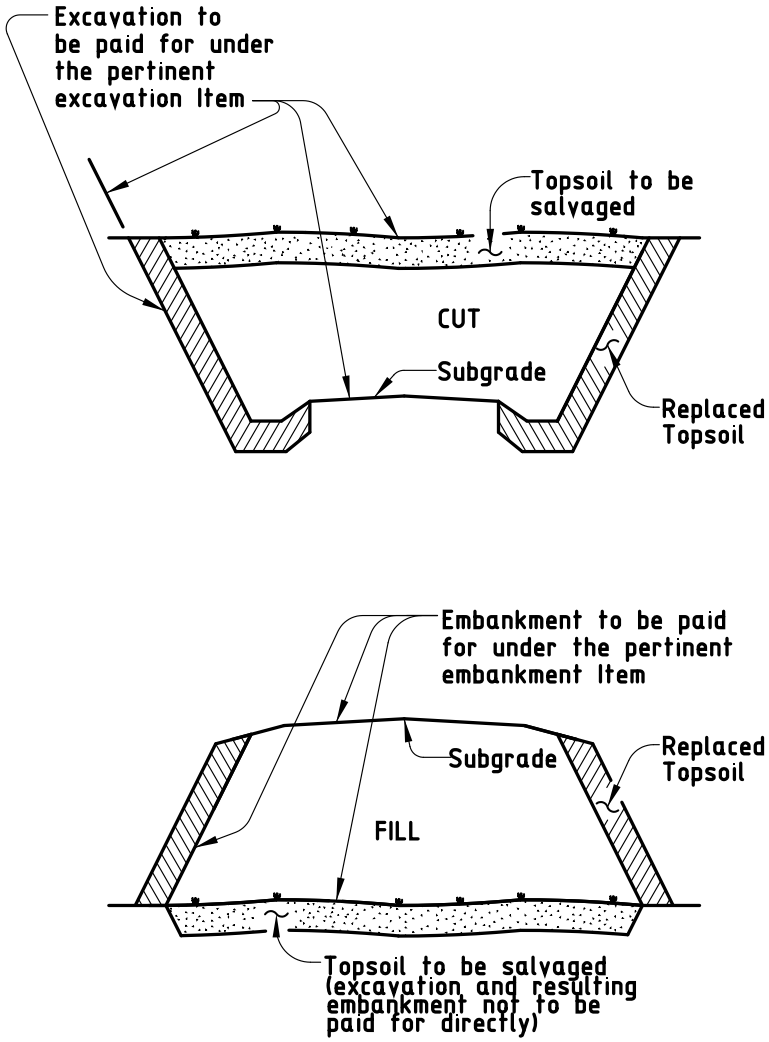


Figure 1
Roadway Cross-Sections Showing Payment for Excavation and Embankment

Item 164
Seeding for Erosion Control

1. DESCRIPTION

Prepare the surface and provide and distribute 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 potassium nitrate (KNO_3) to overcome dormancy.

Use Tables 1–5 to determine the appropriate seeding mix and rates as shown on the plans. Include flower seeding mix in accordance with Table 5 with seeding mix shown in Table 1 and Table 2.

If a grass plant species is not available by the producers, the other grass plant species in the seeding mix will be increased proportionally by the percentage of the missing plant grass species. If a flower plant species is not available by the producers, the other flower species in the seeding mix will be increased proportionally by the percentage of the missing flower species. Substitute species and rates require approval of the Engineer before being incorporated into the seeding mx. The rates listed in the tables are for drill seeding. All other methods of placing seed will require a 25% increase in rate.

Table 1
Permanent Rural Seeding Mix

District	Clay Soils Species, Percent, and Rate (lb. PLS per acre)		Sandy Soils Species, Percent, and Rate (lb. PLS per acre)	
1 (Paris)	Hooded Windmillgrass (Burnet)	15% 0.3	Hooded Windmillgrass (Burnet)	15% 0.3
	White Tridens (Guadalupe)	20% 0.4	Sand Dropseed (Taylor)	15% 0.3
	Little Bluestem (Coastal Plains)	20% 2.0	Little Bluestem (Coastal Plains)	20% 2.0
	Florida Paspalum (Harrison)	15% 2.25	Florida Paspalum (Harrison)	15% 2.25
	Sideoats Grama (Haskell)	05% 0.5	Splitbeard Bluestem (Neches)	10% 1.0
	Splitbeard Bluestem (Neches)	05% 0.5	Sand Lovegrass (Mason)	10% 0.4
	Sand Dropseed (Taylor)	05% 0.1	Green Sprangletop (Van Horn)	15% 0.6
	Canada Wildrye (Lavaca)	10% 2.0		
	Green Sprangletop (Van Horn)	05% 0.2		
2 (Fort Worth)	Hooded Windmillgrass (Burnet)	15% 0.3	Sand Dropseed (Taylor)	15% 0.3
	White Tridens (Guadalupe)	15% 0.3	Sideoats Grama (Haskell)	15% 1.5
	Sideoats Grama (Haskell)	10% 1.0	Little Bluestem (OK Select)	15% 1.05
	Little Bluestem (OK Select)	10% 0.7	Hairy Grama (Chaparral)	15% 0.6
	Buffalograss (Texoka)	10% 1.5	Green Sprangletop (Van Horn)	10% 0.2
	Silver Bluestem (Santiago)	10% 0.4	Hooded Windmillgrass (Burnet)	10% 0.2
	Green Sprangletop (Van Horn)	10% 0.4	Shortspike Windmillgrass (Welder)	10% 0.2
	Sand Dropseed (Taylor)	10% 0.2	Silver Bluestem (Stantiago)	10% 0.4
	Canada Wildrye (Lavaca)	10% 2.0		

Table 1 (continued)
Permanent Rural Seeding Mix

District	Clay Soils Species, Percent, and Rate (lb. PLS per acre)		Sandy Soils Species, Percent, and Rate (lb. PLS per acre)	
3 (Wichita Falls)	Sideoats Grama (Haskell)	15% 1.5	Hooded Windmillgrass (Burnet)	10% 0.2
	Green Sprangletop (Van Horn)	10% 0.4	Sand Dropseed (Taylor)	15% 0.3
	Hooded Windmillgrass (Burnet)	10% 0.2	Green Sprangletop (Van Horn)	15% 0.6
	White Tridens (Guadalupe)	10% 0.2	Sideoats Grama (Haskell)	10% 1.0
	Little Bluestem (OK Select)	15% 1.05	Little Bluestem (OK Select)	10% 0.7
	Silver Bluestem (Santiago)	10% 0.4	Silver Bluestem (Santiago)	10% 0.4
	Buffalograss (Texoka)	10% 1.5	Hairy Grama (Chaparral)	10% 0.4
	Blue Grama (Hachita)	05% 0.2	Arizona Cottontop (La Salle)	10% 0.4
	Sand Dropseed (Taylor)	05% 0.1	Blue Grama (Hachita)	10% 0.4
	Canada Wildrye (Lavaca)	10% 2.0		
4 (Amarillo)	Sideoats Grama (Haskell)	15% 1.5	Green Sprangletop (Van Horn)	15% 0.6
	Silver Bluestem (Santiago)	15% 0.6	Sideoats Grama (Haskell)	10% 1.0
	Buffalograss (Texoka)	15% 2.25	Sand Dropseed (Taylor)	10% 0.2
	Green Sprangletop (Van Horn)	10% 0.4	Silver Bluestem (Santiago)	10% 0.4
	Blue Grama (Hachita)	15% 0.6	Little Bluestem (OK Select)	15% 1.05
	Hooded Windmillgrass (Burnet)	05% 0.1	Arizona Cottontop (La Salle)	10% 0.4
	White Tridens (Guadalupe)	10% 0.2	Blue Grama (Hachita)	10% 0.4
	Western Wheatgrass (Barton)	10% 3.0	Sand Lovegrass (Mason)	10% 0.3
	Canada Wildrye (Lavaca)	05% 1.0	Hooded Windmillgrass (Burnet)	10% 0.2
5 (Lubbock)	Sideoats Grama (Haskell)	15% 1.5	Green Sprangletop (Van Horn)	15% 0.6
	Blue Grama (Hachita)	15% 0.6	Blue Grama (Hachita)	15% 0.6
	Silver Bluestem (Santiago)	15% 0.6	Sideoats Grama (Haskell)	10% 1.0
	Buffalograss (Texoka)	10% 1.5	Little Bluestem (OK Select)	10% 0.7
	White Tridens (Guadalupe)	10% 0.2	Hooded Windmillgrass (Burnet)	10% 0.2
	Green Sprangletop (Van Horn)	10% 0.4	Sand Dropseed (Taylor)	10% 0.2
	Hooded Windmillgrass (Burnet)	05% 0.1	Silver Bluestem (Santiago)	10% 0.4
	Galleta Grass (Viva)	05% 0.3	Arizona Cottontop (La Salle)	10% 0.4
	Western Wheatgrass (Barton)	10% 3.0	Sand Lovegrass (Mason)	10% 0.3
	Canada Wildrye (Lavaca)	05% 1.0		
6 (Odessa)	Whiplash Pappusgrass (Permian)	15% 0.9	Sand Dropseed (Taylor)	15% 0.3
	Green Sprangletop (Van Horn)	10% 0.4	Green Sprangletop (Van Horn)	10% 0.4
	Silver Bluestem (Santiago)	15% 0.6	Sideoats Grama (Brewster)	15% 1.5
	Sideoats Grama (Brewster)	10% 1.0	Whiplash Pappusgrass (Permian)	10% 0.6
	Sand Dropseed (Taylor)	10% 0.2	Hooded Windmillgrass (Burnet)	10% 0.2
	Alkali Sacaton (Saltalk)	10% 0.2	Blue Grama (Hachita)	10% 0.4
	Arizona Cottontop (La Salle)	10% 0.4	Hairy Grama (Chaparral)	10% 0.4
	Blue Grama (Hachita)	10% 0.4	Sand Lovegrass (Mason)	10% 0.3
	Galleta Grass (Viva)	10% 0.6	Little Bluestem (Pastura)	05% 0.5
			Galleta Grass (Viva)	05% 0.3
7 (San Angelo)	Sideoats Grama (Brewster)	15% 1.5	Sand Dropseed (Taylor)	15% 0.3
	Hooded Windmillgrass (Burnet)	10% 0.2	Green Sprangletop (Van Horn)	15% 0.6
	Silver Bluestem (Santiago)	10% 0.4	Hooded Windmillgrass (Burnet)	15% 0.3
	Sand Dropseed (Taylor)	10% 0.2	Shortspike Windmillgrass (Welder)	10% 0.2
	White Tridens (Guadalupe)	10% 0.2	Hairy Grama (Chaparral)	10% 0.4
	Whiplash Pappusgrass (Permian)	15% 0.9	Sand Lovegrass (Mason)	10% 0.3
	Texas Grama (Atascosa)	05% 0.5	Sideoats Grama (Brewster)	10% 1.0
	Green Sprangletop (Van Horn)	10% 0.4	Little Bluestem (OK Select)	10% 0.7
	Little Bluestem (OK Select)	05% 0.35	Whiplash Pappusgrass (Permian)	05% 0.3
	Blue Grama (Hachita)	05% 0.2		
	Galleta Grass (Viva)	05% 0.3		

Table 1 (continued)
Permanent Rural Seeding Mix

District	Clay Soils Species, Percent, and Rate (lb. PLS per acre)		Sandy Soils Species, Percent, and Rate (lb. PLS per acre)	
8 (Abilene)	Sideoats Grama (Haskell)	10% 1.0	Sand Dropseed (Taylor)	15% 0.3
	Hooded Windmillgrass (Burnet)	10% 0.2	Green Sprangletop (Van Horn)	10% 0.4
	Buffalograss (Texoka)	10% 1.5	Hooded Windmillgrass (Burnet)	15% 0.3
	Blue Grama (Hachita)	10% 0.4	Silver Bluestem (Santiago)	10% 0.4
	Silver Bluestem (Santiago)	10% 0.4	Little Bluestem (OK Select)	10% 0.7
	White Tridens (Guadalupe)	15% 0.2	Shortspike Windmillgrass (Welder)	10% 0.2
	Little Bluestem (OK Select)	10% 0.7	Hairy Grama (Chaparral)	10% 0.4
	Green Sprangletop (Van Horn)	10% 0.4	Sand Lovegrass (Mason)	10% 0.3
	Whiplash Pappusgrass (Permian)	10% 0.6	Arizona Cottontop (La Salle)	10% 0.4
	Galleta Grass (Viva)	10% 0.6		
9 (Waco)	Sideoats Grama (Haskell)	15% 1.5	Hooded Windmillgrass (Burnet)	15% 0.3
	White Tridens (Guadalupe)	15% 0.3	Shortspike Windmillgrass (Welder)	10% 0.2
	Hooded Windmillgrass (Burnet)	10% 0.2	Hairy Grama (Chaparral)	10% 0.4
	Little Bluestem (OK Select)	10% 0.7	Sand Dropseed (Taylor)	15% 0.3
	Buffalograss (Texoka)	10% 1.6	Sideoats Grama (Haskell)	10% 1.0
	Halls Panicum (Oso)	05% 0.1	Little Bluestem (OK Select)	10% 0.7
	Silver Bluestem (Santiago)	10% 0.4	Green Sprangletop (Van Horn)	10% 0.4
	Sand Dropseed (Taylor)	05% 0.1	Texas Grama (Atascosa)	05% 0.15
	Green Sprangletop (Van Horn)	10% 0.4	Silver Bluestem (Santiago)	10% 0.4
	Canada Wildrye (Lavaca)	05% 1.0	Canada Wildrye (Lavaca)	05% 1.0
	Texas Grama (Atascosa)	05% 0.5		
10 (Tyler)	Hooded Windmillgrass (Burnet)	15% 0.3	Hooded Windmillgrass (Burnet)	15% 0.3
	White Tridens (Guadalupe)	15% 0.3	Sand Dropseed (Taylor)	10% 0.2
	Sand Dropseed (Taylor)	05% 0.1	Little Bluestem (Coastal Plains)	20% 2.0
	Little Bluestem (Coastal Plains)	20% 2.0	Florida Paspalum (Harrison)	15% 2.25
	Florida Paspalum (Harrison)	15% 2.25	Splitbeard Bluestem (Neches)	10% 1.0
	Splitbeard Bluestem (Neches)	10% 1.0	Green Sprangletop (Van Horn)	05% 0.2
	Green Sprangletop (Van Horn)	05% 0.2	Sand Lovegrass (Mason)	10% 0.4
	Sideoats Grama (Haskell)	05% 0.5	Red Lovegrass (Duval)	10% 0.2
	Canada Wildrye (Lavaca)	10% 2.0	Hairy Grama (Chaparral)	05% 0.2
11 (Lufkin)	Hooded Windmillgrass (Burnet)	15% 0.3	Hooded Windmillgrass (Burnet)	15% 0.3
	White Tridens (Guadalupe)	15% 0.3	Sand Dropseed (Taylor)	10% 0.2
	Little Bluestem (Coastal Plains)	20% 2.0	Little Bluestem (Coastal Plains)	20% 2.0
	Florida Paspalum (Harrison)	15% 2.25	Florida Paspalum (Harrison)	15% 2.25
	Green Sprangletop (Van Horn)	05% 0.2	Splitbeard Bluestem (Neches)	10% 1.0
	Sideoats Grama (Haskell)	05% 0.5	Green Sprangletop (Van Horn)	05% 0.2
	Splitbeard Bluestem (Neches)	10% 1.0	Red Lovegrass (Duval)	10% 0.2
	Sand Dropseed (Taylor)	05% 0.1	Sand Lovegrass (Mason)	10% 0.4
	Canada Wildrye (Lavaca)	10% 2.0	Hairy Grama (Chaparral)	05% 0.2
12 (Houston)	White Tridens (Guadalupe)	10% 0.2	Hooded Windmillgrass (Mariah)	15% 0.3
	Hooded Windmillgrass (Mariah)	10% 0.2	Sand Dropseed (Nueces)	15% 0.3
	Shortspike Windmillgrass (Welder)	15% 0.3	Shortspike Windmillgrass (Welder)	10% 0.2
	Little Bluestem (Coastal Plains)	15% 1.5	Little Bluestem (Coastal Plains)	15% 1.5
	Florida Paspalum (Harrison)	15% 2.25	Red Lovegrass (Duval)	10% 0.2
	Red Lovegrass (Duval)	05% 0.1	Florida Paspalum (Harrison)	15% 2.25
	Halls Panicum (Oso)	10% 0.2	Splitbeard Bluestem (Neches)	10% 1.0
	Splitbeard Bluestem (Neches)	05% 0.5	Hairy Grama (Chaparral)	05% 0.2
	Sand Dropseed (Nueces)	05% 0.1	Green Sprangletop (Van Horn)	05% 0.2
	Canada Wildrye (Lavaca)	10% 2.0		

Table 1 (continued)
Permanent Rural Seeding Mix

District	Clay Soils Species, Percent, and Rate (lb. PLS per acre)		Sandy Soils Species, Percent, and Rate (lb. PLS per acre)	
13 (Yoakum)	White Tridens (Guadalupe)	15% 0.3	Hairy Grama (Chaparral)	15% 0.6
	Shortspike Windmillgrass (Welder)	15% 0.3	Hooded Windmillgrass (Mariah)	15% 0.3
	Halls Panicum (Oso)	10% 0.2	Shortspike Windmillgrass (Welder)	10% 0.2
	Plains Bristlegrass (Catarina Blend)	10% 0.6	Sand Dropseed (Nueces)	10% 0.2
	Little Bluestem (Coastal Plains)	15% 1.5	Little Bluestem (Carrizo)	10% 1.5
	Sideoats Grama (South Texas)	05% 0.75	Red Lovegrass (Duval)	10% 0.2
	Texas Grama (Atascosa)	10% 1.0	Slender Grama (Dilley)	10% 1.0
	Hooded Windmillgrass (Mariah)	05% 0.1	Plains Bristlegrass (Catarina)	10% 0.4
	Sand Dropseed (Nueces)	05% 0.1	Green Sprangletop (Van Horn)	10% 0.4
	Canada Wildrye (Lavaca)	10% 2.0		
14 (Austin)	Hooded Windmillgrass (Burnet)	20% 0.4	Hairy Grama (Chaparral)	15% 0.6
	White Tridens (Guadalupe)	10% 0.2	Shortspike Windmillgrass (Welder)	10% 0.2
	Sideoats Grama (South Texas)	10% 1.5	Hooded Windmillgrass (Burnet)	10% 0.2
	Shortspike Windmillgrass (Welder)	10% 0.2	Red Lovegrass (Duval)	10% 0.2
	Plains Bristlegrass (Catarina Blend)	10% 0.6	Sand Dropseed (Nueces)	10% 0.2
	Silver Bluestem (Santiago)	10% 0.4	Little Bluestem (Carrizo)	10% 1.5
	Little Bluestem (OK Select)	10% 0.7	Sideoats Grama (South Texas)	10% 1.5
	Halls Panicum (Oso)	05% 0.1	Silver Bluestem (Santiago)	10% 0.4
	Texas Grama (Atascosa)	05% 0.5	Plains Bristlegrass (Catarina)	10% 0.4
	Canada Wildrye (Lavaca)	10% 2.0	Arizona Cottontop (La Salle)	05% 0.2
15 (San Antonio)	Sideoats Grama (South Texas)	15% 2.25	Slender Grama (Dilley)	15% 1.5
	White Tridens (Guadalupe)	15% 0.3	Hairy Grama (Chaparral)	15% 0.6
	Shortspike Windmillgrass (Welder)	10% 0.2	Shortspike Windmillgrass (Welder)	10% 0.2
	Halls Panicum (Oso)	10% 0.2	Hooded Windmillgrass (Mariah)	10% 0.2
	Plains Bristlegrass (Catarina Blend)	10% 0.6	Red Lovegrass (Duval)	10% 0.2
	False Rhodes Grass (Kinney)	05% 0.1	Sand Dropseed (Nueces)	10% 0.2
	Hooded Windmillgrass (Mariah)	05% 0.1	Pink Pappusgrass (Maverick)	05% 0.3
	Pink Pappusgrass (Maverick)	10% 0.6	Little Bluestem (Carrizo)	10% 1.5
	Texas Grama (Atascosa)	05% 0.5	Arizona Cottontop (La Salle)	05% 0.2
	Multiflower False Rhodes Grass (Hidalgo)	10% 0.2	Multiflower False Rhodes Grass (Hidalgo)	05% 0.1
	Arizona Cottontop (La Salle)	05% 0.2	Plains Bristlegrass (Catarina)	05% 0.2
16 (Corpus Christi)	Shortspike Windmillgrass (Welder)	15% 0.3	Slender Grama (Dilley)	15% 1.5
	Pink Pappusgrass (Maverick)	10% 0.6	Hairy Grama (Chaparral)	15% 0.6
	Halls Panicum (Oso)	10% 0.2	Hooded Windmillgrass (Mariah)	10% 0.2
	Plains Bristlegrass (Catarina Blend)	10% 0.6	Red Lovegrass (Duval)	10% 0.2
	White Tridens (Guadalupe)	10% 0.2	Sand Dropseed (Nueces)	10% 0.2
	Multiflower Galse Rhodes Grass (Hidalgo)	10% 0.2	Shortspike Windmillgrass (Welder)	10% 0.2
			Pink Pappusgrass (Maverick)	10% 0.6
	Hooded Windmillgrass (Mariah)	10% 0.2	Multiflower False Rhodes Grass	10% 0.2
	Arizona Cottontop (La Salle)	05% 0.2	(Hidalgo)	
	Sand Dropseed (Nueces)	05% 0.1	Arizona Cottontop (La Salle)	05% 0.2
	Sideoats Grama (South Texas)	10% 1.5	Little Bluestem (Carrizo)	05% 0.75
	Texas Grama (Atascosa)	05% 0.5		
17 (Bryan)	White Tridens (Guadalupe)	15% 0.3	Sand Dropseed (Taylor)	10% 0.2
	Hooded Windmillgrass (Burnet)	15% 0.3	Shortspike Windmillgrass (Welder)	10% 0.2
	Little Bluestem (Coastal Plains)	15% 1.5	Little Bluestem (Coastal Plains)	15% 1.5
	Florida Paspalum (Harrison)	15% 2.25	Green Sprangletop (Van Horn)	05% 0.2
	Shortspike Windmillgrass (Welder)	10% 0.2	Florida Paspalum (Harrison)	15% 2.25
	Splitbeard Bluestem (Neches)	05% 0.5	Splitbeard Bluestem (Neches)	10% 1.0
	Green Sprangletop (Van Horn)	05% 0.2	Hooded Windmillgrass (Burnet)	15% 0.3
	Halls Panicum (Oso)	05% 0.1	Red Lovegrass (Duval)	10% 0.2
	Sand Dropseed (Taylor)	05% 0.1	Hairy Grama (Chaparral)	10% 0.4
	Canada Wildrye (Lavaca)	10% 2.0		

Table 1 (continued)
Permanent Rural Seeding Mix

District	Clay Soils Species, Percent, and Rate (lb. PLS per acre)		Sandy Soils Species, Percent, and Rate (lb. PLS per acre)	
18 (Dallas)	Sideoats Grama (Haskell)	15% 1.5	Shortspike Windmillgrass (Welder)	10% 0.2
	Hooded Windmillgrass (Burnet)	15% 0.3	Hairy Grama (Chaparral)	15% 0.6
	White Tridens (Guadalupe)	15% 0.3	Sand Dropseed (Taylor)	10% 0.2
	Little Bluestem (OK Select)	15% 1.05	Little Bluestem (OK Select)	15% 1.05
	Buffalograss (Texoka)	10% 1.5	Sideoats Grama (Haskell)	10% 1.0
	Silver Bluestem (Santiago)	05% 0.2	Green Sprangletop (Van Horn)	10% 0.4
	Green Sprangletop (Van Horn)	05% 0.2	Hooded Windmillgrass (Burnet)	10% 0.2
	Shortspike Windmillgrass (Welder)	05% 0.1	Sand Lovegrass (Mason)	10% 0.4
	Canada Wildrye (Lavaca)	10% 2.0	Silver Bluestem (Santiago)	10% 0.4
	Sand Dropseed (Taylor)	05% 0.1		
19 (Atlanta)	White Tridens (Guadalupe)	15% 0.3	Hooded Windmillgrass (Burnet)	15% 0.3
	Hooded Windmillgrass (Burnet)	15% 0.3	Sand Dropseed (Taylor)	10% 0.2
	Little Bluestem (Coastal Plains)	20% 2.0	Little Bluestem (Coastal Plains)	20% 2.0
	Florida Paspalum (Harrison)	15% 2.25	Florida Paspalum (Harrison)	15% 2.25
	Sideoats Grama (Haskell)	10% 1.0	Splitbeard Bluestem (Neches)	10% 1.0
	Splitbeard Bluestem (Neches)	05% 0.5	Sand Lovegrass (Mason)	10% 0.4
	Green Sprangletop (Van Horn)	05% 0.2	Red Lovegrass (Duval)	10% 0.2
	Sand Dropseed (Taylor)	05% 0.1	Hairy Grama (Chaparral)	10% 0.4
	Canada Wildrye (Lavaca)	10% 2.0		
20 (Beaumont)	White Tridens (Guadalupe)	10% 0.2	Hooded Windmillgrass (Mariah)	15% 0.3
	Hooded Windmillgrass (Mariah)	10% 0.2	Sand Dropseed (Nueces)	15% 0.3
	Shortspike Windmillgrass (Welder)	15% 0.3	Shortspike Windmillgrass (Welder)	10% 0.2
	Little Bluestem (Coastal Plains)	15% 1.5	Little Bluestem (Coastal Plains)	15% 1.5
	Florida Paspalum (Harrison)	15% 2.25	Red Lovegrass (Duval)	10% 0.2
	Red Lovegrass (Duval)	05% 0.1	Florida Paspalum (Harrison)	15% 2.25
	Halls Panicum (Oso)	10% 0.2	Splitbeard Bluestem (Neches)	10% 1.0
	Splitbeard Bluestem (Neches)	05% 0.5	Hairy Grama (Chaparral)	05% 0.2
	Sand Dropseed (Nueces)	05% 0.1	Green Sprangletop (Van Horn)	05% 0.2
	Canada Wildrye (Lavaca)	10% 2.0		
21 (Pharr)	Shortspike Windmillgrass (Welder)	10% 0.2	Slender Grama (Dilley)	10% 1.0
	Halls Panicum (Oso)	10% 0.2	Hairy Grama (Chaparral)	10% 0.4
	White Tridens (Guadalupe)	10% 0.2	Shortspike Windmillgrass (Welder)	10% 0.2
	Plains Bristlegrass (Catarina Blend)	10% 0.6	Red Lovegrass (Duval)	10% 0.2
	Pink Pappusgrass (Maverick)	10% 0.6	Sand Dropseed (Nueces)	10% 0.2
	Texas Grama (Atascosa)	10% 1.0	Hooded Windmillgrass (Mariah)	10% 0.2
	Multiflower False Rhodes Grass (Hidalgo)	05% 0.1	Pink Pappusgrass (Maverick)	10% 0.6
			Whiplash Pappusgrass (Webb)	10% 0.6
	Hooded Windmillgrass (Mariah)	10% 0.2	Multiflower False Rhodes Grass (Hidalgo)	10% 0.2
	Arizona Cottontop (La Salle)	10% 0.4		
	Sand Dropseed (Nueces)	05% 0.1	Arizona Cottontop (La Salle)	10% 0.4
	Whiplash Pappusgrass (Webb)	10% 0.6		
22 (Laredo)	Sideoats Grama (South Texas)	15% 2.25	Slender Grama (Dilley)	15% 1.5
	Pink Pappusgrass (Maverick)	10% 0.6	Hairy Grama (Chaparral)	15% 0.6
	Halls Panicum (Oso)	10% 0.2	Hooded Windmillgrass (Mariah)	10% 0.2
	Plains Bristlegrass (Catarina Blend)	10% 0.6	Red Lovegrass (Duval)	10% 0.2
	White Tridens (Guadalupe)	10% 0.2	Sand Dropseed (Nueces)	10% 0.2
	Whiplash Pappusgrass (Webb)	10% 0.6	Pink Pappusgrass (Maverick)	10% 0.6
	Shortspike Windmillgrass (Welder)	05% 0.1	Arizona Cottontop (La Salle)	10% 0.4
	Texas Grama (Atascosa)	10% 1.0	Little Bluestem (Carrizo)	05% 0.75
	False Rhodes Grass (Kinney)	10% 0.2	Sideoats Grama (South Texas)	10% 1.5
	Hooded Windmillgrass (Mariah)	10% 0.2	Shortspike Windmillgrass (Welder)	05% 0.1

Table 1 (continued)
Permanent Rural Seeding Mix

District	Clay Soils Species, Percent, and Rate (lb. PLS per acre)		Sandy Soils Species, Percent, and Rate (lb. PLS per acre)	
23 (Brownwood)	Sideoats Grama (Haskell)	15% 1.5	Green Sprangletop (Van Horn)	15% 0.6
	Hooded Windmillgrass (Burnet)	15% 0.3	Sand Dropseed (Taylor)	15% 0.3
	White Tridens (Guadalupe)	15% 0.3	Sideoats Grama (Haskell)	10% 1.0
	Texas Grama (Atascosa)	10% 1.0	Little Bluestem (OK Select)	15% 1.05
	Little Bluestem (OK Select)	10% 0.7	Silver Bluestem (Santiago)	10% 0.4
	Buffalograss (Texoka)	10% 1.5	Hooded Windmillgrass (Burnet)	10% 0.2
	Silver Bluestem (Santiago)	10% 0.4	Shortspike Windmillgrass (Welder)	10% 0.2
	Shortspike Windmillgrass (Welder)	05% 0.1	Hairy Grama (Chaparral)	10% 0.4
	Sand Dropseed (Taylor)	05% 0.1	Sand Lovegrass (Mason)	05% 0.2
	Green Sprangletop (Van Horn)	05% 0.2		
24 (El Paso)	Green Sprangletop (Van Horn)	10% 0.4	Sand Dropseed (Taylor)	20% 0.4
	Sideoats Grama (Brewster)	10% 1.0	Sideoats Grama (Brewster)	15% 1.5
	Whiplash Pappusgrass (Permian)	10% 0.6	Green Sprangletop (Van Horn)	15% 0.6
	Silver Bluestem (Santiago)	10% 0.4	Hooded Windmillgrass (Burnet)	10% 0.2
	Blue Grama (Hachita)	10% 0.4	Blue Grama (Hachita)	10% 0.4
	Galleta Grass (Viva)	10% 0.6	Hairy Grama (Chaparral)	05% 0.2
	Alkali Sacaton (Saltalk)	10% 0.2	Spike Dropseed (Potter)	10% 0.1
	Arizona Cottontop (La Salle)	10% 0.4	Little Bluestem (Pastura)	05% 0.5
	Plains Bristlegrass (Catarina Blend)	10% 0.4	Galleta grass (Viva)	10% 0.6
	False Rhodes Grass (Kinney)	10% 0.2		
25 (Childress)	Sideoats Grama (Haskell)	15% 1.5	Sideoats Grama (Haskell)	15% 1.5
	Hooded Windmillgrass (Burnet)	15% 0.3	Green Sprangletop (Van Horn)	10% 0.4
	Blue Grama (Hachita)	10% 0.4	Sand Dropseed (Taylor)	10% 0.2
	Buffalograss (Texoka)	10% 1.5	Hooded Windmillgrass (Burnet)	10% 0.2
	Galleta Grass (Viva)	10% 0.6	Arizona Cottontop (La Salle)	10% 0.4
	Silver Bluestem (Santiago)	15% 0.6	Blue Grama (Hachita)	10% 0.4
	White Tridens (Guadalupe)	10% 0.2	Little Bluestem (OK select)	10% 1.0
	Green Sprangletop (Van Horn)	05% 0.2	Galleta Grass (Viva)	10% 0.6
	Western Wheatgrass (Barton)	05% 1.5	Sand Lovegrass (Mason)	05% 0.15
	Canada Wildrye (Lavaca)	05% 1.0	Canada Wildrye (Lavaca)	10% 2.0

Table 2
Permanent Urban Seeding Mix

District	Clay Soils Species and Rates (lb. PLS per acre)		Sandy Soils Species and Rates (lb. PLS per acre)	
1 (Paris)	Green Sprangletop	0.3	Green Sprangletop	0.3
	Bermudagrass	2.4	Bermudagrass	5.4
	Sideoats Grama (Haskell)	4.5		
2 (Fort Worth)	Green Sprangletop	0.3	Green Sprangletop	0.3
	Sideoats Grama (El Reno)	3.6	Sideoats Grama (El Reno)	3.6
	Bermudagrass	2.4	Bermudagrass	2.1
	Buffalograss (Texoka)	1.6	Sand Dropseed (Borden Co.)	0.3
3 (Wichita Falls)	Green Sprangletop	0.3	Green Sprangletop	0.3
	Sideoats Grama (El Reno)	4.5	Sideoats Grama (El Reno)	3.6
	Bermudagrass	1.8	Bermudagrass	1.8
	Buffalograss (Texoka)	1.6	Sand Dropseed (Borden Co.)	0.4
4 (Amarillo)	Green Sprangletop	0.3	Green Sprangletop	0.3
	Sideoats Grama (El Reno)	3.6	Sideoats Grama (El Reno)	2.7
	Blue Grama (Hachita)	1.2	Blue Grama (Hachita)	0.9
	Buffalograss (Texoka)	1.6	Sand Dropseed (Borden Co.)	0.4
			Buffalograss (Texoka)	1.6
5 (Lubbock)	Green Sprangletop	0.3	Green Sprangletop	0.3
	Sideoats Grama (El Reno)	3.6	Sideoats Grama (El Reno)	2.7
	Blue Grama (Hachita)	1.2	Blue Grama (Hachita)	0.9
	Buffalograss (Texoka)	1.6	Sand Dropseed (Borden Co.)	0.4
			Buffalograss (Texoka)	1.6

Table 2 (continued)
Permanent Urban Seeding Mix

District	Clay Soils Species and Rates (lb. PLS per acre)		Sandy Soils Species and Rates (lb. PLS per acre)	
6 (Odessa)	Green Sprangletop	0.3	Green Sprangletop	0.3
	Sideoats Grama (Haskell)	3.6	Sideoats Grama (Haskell)	2.7
	Blue Grama (Hachita)	1.2	Sand Dropseed (Borden Co.)	0.4
	Buffalograss (Texoka)	1.6	Blue Grama (Hachita)	0.9
			Buffalograss (Texoka)	1.6
7 (San Angelo)	Green Sprangletop	0.3	Green Sprangletop	0.3
	Sideoats Grama (Haskell)	7.2	Sideoats Grama (Haskell)	3.2
	Buffalograss (Texoka)	1.6	Sand Dropseed (Borden Co.)	0.3
			Blue Grama (Hachita)	0.9
			Buffalograss (Texoka)	1.6
8 (Abilene)	Green Sprangletop	0.3	Green Sprangletop	0.3
	Sideoats Grama (Haskell)	3.6	Sand Dropseed (Borden Co.)	0.3
	Blue Grama (Hachita)	1.2	Sideoats Grama (Haskell)	3.6
	Buffalograss (Texoka)	1.6	Blue Grama (Hachita)	0.8
			Buffalograss (Texoka)	1.6
9 (Waco)	Green Sprangletop	0.3	Green Sprangletop	0.3
	Bermudagrass	1.8	Buffalograss (Texoka)	1.6
	Buffalograss (Texoka)	1.6	Bermudagrass	3.6
	Sideoats Grama (Haskell)	4.5	Sand Dropseed (Borden Co.)	0.4
10 (Tyler)	Green Sprangletop	0.3	Green Sprangletop	0.3
	Bermudagrass	2.4	Bermudagrass	5.4
	Sideoats Grama (Haskell)	4.5		
11 (Lufkin)	Green Sprangletop	0.3	Green Sprangletop	0.3
	Bermudagrass	2.4	Bermudagrass	5.4
	Sideoats Grama (Haskell)	4.5		
12 (Houston)	Green Sprangletop	0.3	Green Sprangletop	0.3
	Sideoats Grama (Haskell)	4.5	Bermudagrass	5.4
	Bermudagrass	2.4		
13 (Yoakum)	Green Sprangletop	0.3	Green Sprangletop	0.3
	Sideoats Grama (South Texas)	4.5	Bermudagrass	5.4
	Bermudagrass	2.4		
14 (Austin)	Green Sprangletop	0.3	Green Sprangletop	0.3
	Bermudagrass	2.4	Bermudagrass	4.8
	Sideoats Grama (South Texas)	3.6	Buffalograss (Texoka)	1.6
	Buffalograss (Texoka)	1.6		
15 (San Antonio)	Green Sprangletop	0.3	Green Sprangletop	0.3
	Sideoats Grama (South Texas)	3.6	Bermudagrass	4.8
	Bermudagrass	2.4	Buffalograss (Texoka)	1.6
	Buffalograss (Texoka)	1.6		
16 (Corpus Christi)	Green Sprangletop	0.3	Green Sprangletop	0.3
	Sideoats Grama (South Texas)	3.6	Bermudagrass	4.8
	Bermudagrass	2.4	Buffalograss (Texoka)	1.6
	Buffalograss (Texoka)	1.6		
17 (Bryan)	Green Sprangletop	0.3	Green Sprangletop	0.3
	Bermudagrass	2.4	Bermudagrass	5.4
	Sideoats Grama (Haskell)	4.5		
18 (Dallas)	Green Sprangletop	0.3	Green Sprangletop	0.3
	Sideoats Grama (El Reno)	3.6	Buffalograss (Texoka)	1.6
	Buffalograss (Texoka)	1.6	Bermudagrass	3.6
	Bermudagrass	2.4	Sand Dropseed (Borden Co.)	0.4
19 (Atlanta)	Green Sprangletop	0.3	Green Sprangletop	0.3
	Bermudagrass	2.4	Bermudagrass	5.4
	Sideoats Grama (Haskell)	4.5		
20 (Beaumont)	Green Sprangletop	0.3	Green Sprangletop	0.3
	Bermudagrass	2.4	Bermudagrass	5.4
	Sideoats Grama (Haskell)	4.5		

Table 2 (continued)
Permanent Urban Seeding Mix

District	Clay Soils Species and Rates (lb. PLS per acre)		Sandy Soils Species and Rates (lb. PLS per acre)	
21 (Pharr)	Green Sprangletop	0.3	Green Sprangletop	0.3
	Sideoats Grama (South Texas)	3.6	Buffalograss (Texoka)	1.6
	Buffalograss (Texoka)	1.6	Bermudagrass	3.6
	Bermudagrass	2.4	Sand Dropseed (Borden Co.)	0.4
22 (Laredo)	Green Sprangletop	0.3	Green Sprangletop	0.3
	Sideoats Grama (South Texas)	4.5	Buffalograss (Texoka)	1.6
	Buffalograss (Texoka)	1.6	Bermudagrass	3.6
	Bermudagrass	1.8	Sand Dropseed	0.4
23 (Brownwood)	Green Sprangletop	0.3	Green Sprangletop	0.3
	Sideoats Grama (Haskell)	3.6	Buffalograss (Texoka)	1.6
	Bermudagrass	1.2	Bermudagrass	3.6
	Blue Grama (Hachita)	0.9	Sand Dropseed (Borden Co.)	0.4
24 (El Paso)	Green Sprangletop	0.3	Green Sprangletop	0.3
	Sideoats Grama (South Texas)	3.6	Buffalograss (Texoka)	1.6
	Blue Grama (Hachita)	1.2	Sand Dropseed (Borden Co.)	0.4
	Buffalograss (Texoka)	1.6	Blue Grama (Hachita)	1.8
25 (Childress)	Green Sprangletop	0.3	Green Sprangletop	0.3
	Sideoats Grama (El Reno)	3.6	Sand Dropseed (Borden Co.)	0.4
	Blue Grama (Hachita)	1.2	Buffalograss (Texoka)	1.6
	Buffalograss (Texoka)	1.6	Bermudagrass	1.8

Table 3
Temporary Cool Seeding Mix

District	All Soils Species and Rates (lb. PLS per acre)	
1 (Paris), 2 (Fort Worth), 3 (Wichita Falls), 4 (Amarillo), 5 (Lubbock), 6 (Odessa), 7 (San Angelo), 8 (Abilene), 18 (Dallas), 19 (Atlanta), 23 (Brownwood), 24 (El Paso), 25 (Childress)	Oats	30.0
	Wheat	30.0
	Little Barley	5.0
	Western Wheatgrass	5.0
9 (Waco), 10 (Tyler), 11 (Lufkin), 12 (Houston), 13 (Yoakum), 14 (Austin), 15 (San Antonio), 16 (Corpus Christi), 17 (Bryan), 20 (Beaumont), 21 (Pharr), 22 (Laredo)	Oats	40.0
	Little Barley	5.0

Table 4
Temporary Warm Seeding Mix

District	All Soils Species and Rates (lb. PLS per acre)	
All	Brownton Millet	20.0

Table 5
Flower Seeding Mix

District	All Soils Species and Rates (lb. PLS per acre)	
1 (Paris), 10 (Tyler), 11 (Lufkin), 12 (Houston), 17 (Bryan), 19 (Atlanta), 20 (Beaumont)	Herbaceous Mimosa (Crockett) Illinois Bundleflower (Sabine) Thickspike Gayfeather (Pineywoods) Purple Prairie Clover (Kaneb) Rio Grange Clammyweed (Zapata)	1.5 1.5 1.5 0.6 2.0
2 (Fort Worth), 3 (Wichita Falls), 4 (Amarillo), 5 (Lubbock), 6 (Odessa), 7 (San Angelo), 8 (Abilene), 9 (Waco), 18 (Dallas), 23 (Brownwood), 25 (Childress)	Engelmann Daisy (Eldorado) Awnless Bushsunflower (Plateau) Partridge Pea Illinois Bundleflower (Sabine) Rio Grande Clammyweed (Zapata)	1.5 1.5 1.5 1.5 2.0
13 (Yoakum), 14 (Austin), 15 (San Antonio), 16 (Corpus Christi, 21 (Pharr), 22 (Laredo), 24 (El Paso)	Indian Blanket (Fuego) Awnless Bushsunflower (Venado) Prostrate Bundleflower (Balli) Orange Zexmenia (Goliad) Rio Grande Clammyweed (Zapata)	1.0 0.4 1.5 0.4 2.0

2.2. **Fertilizer**. Use fertilizer in accordance with Article 166.2., “Materials.”

2.3. **Water**. Use water in accordance with Article 168.2, “Materials.”

2.4. **Highly Erodible Land (HEL)**. Add Bermudagrass to the mix shown in Table 1 at 1.0 PLS per acre if shown on the plans.

2.5. **Mulch**.

2.5.1. **Straw or Hay Mulch**. Use straw or hay mulch in accordance with Section 162.2.5., “Mulch.”

2.5.2. **Hydro Mulch**. Use mulches that are on the Approved Products List. Submit one full set of manufacturer’s literature for the selected material. Keep mulch dry until applied. Do not use molded or rotted material.

2.6. **Tacking Methods**. Use a tacking agent applied in conformance with the manufacturer’s recommendations or by a crimping method on all straw or hay mulch operations. Use tacking agents as approved or as shown on the plans.

3. CONSTRUCTION

Scarify 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. Scarify the seedbed to a depth of 4 in. or mow the area before placement of the permanent seed mix when performing permanent seeding after an established temporary seeding. Plant the seed mix specified and mulch, if required, after the area has been completed to lines and grades as shown on the plans.

Apply fertilizer in accordance with Article 166.3., “Construction.” Grass seed, flower seed, and fertilizer may be distributed simultaneously during dry seeding operations, provided each component is applied at the specified rate. Do not combine fertilizer and seed in the same slurry during hydro mulch seeding operations. 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.

Distribute the seed or seed mixture uniformly over the areas shown on the plans. Provide equipment with an agitator or method to maintain a uniform seed mixture during distribution.

3.1. **Planting Season**.

3.1.1. **Temporary Seed**. Plant cool seeding mix September 1–January 31. Plant warm seeding mix February 1–August 30.

3.1.2. **Permanent Seed**. End planting season for all Districts by May 15. Begin planting season for each District based on the following.

- **January 15**. 1 (Paris), 10 (Tyler), 11 (Lufkin), 12 (Houston), 13 (Yoakum), 15 (San Antonio), 16 (Corpus Christi), 17 (Bryan), 19 (Atlanta), 20 (Beaumont), 21 (Pharr), and 22 (Laredo).
- **February 1**. 2 (Fort Worth), 3 (Wichita Falls), 6 (Odessa), 7 (San Angelo), 8 (Abilene), 9 (Waco), 14 (Austin), 18 (Dallas), 23 (Brownwood), 24 (El Paso), and 25 (Childress).
- **February 15**. 4 (Amarillo) and 5 (Lubbock).

3.2. **Broadcast Seeding**. Use 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 using a light roller or other suitable equipment. Roll sloped areas along the contour of the slopes.

3.3. **Straw or Hay Mulch Seeding**. Plant seed in accordance with Section 164.3.2., "Broadcast Seeding." Apply straw or hay mulch uniformly over the seeded area immediately after planting the seed or seed mixture. Apply straw or hay mulch in accordance with Section 164.3.6., "Straw or Hay Mulching." Apply tack in accordance with Section 164.2.6., "Tacking Methods."

3.4. **Hydro Mulch Seeding**. Plant seed in accordance with Section 164.3.2, "Broadcast Seeding," before placing mulch. Apply 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.

Mulch rates are based on dry weight of mulch per acre. Mix mulch and water to make a slurry and apply uniformly over the seeded area using suitable equipment.

3.5. **Drill Seeding**. Plant at a depth of 1/4–1/3 in. using a pasture- or rangeland-type drill unless otherwise directed. Plant seed along the contour of the slopes.

3.6. **Straw or Hay Mulching**. Apply straw or hay mulch uniformly over the area as shown on the plans. Apply straw mulch at 2–2.5 ton per acre. Apply hay mulch at 1.5–2 ton per acre. Use a tacking method over the mulched area in accordance with Section 164.2.6., "Tacking Methods."

4. MEASUREMENT

This Item will be measured by the square yard or by the acre.

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 "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, "Hydro Mulch Seeding (Perm)" of the rural or urban seed mixture and sandy or clay soil specified, "Hyrdro 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, seeding mix, flower seeding mix, HEL seeding mix, water for hydro-seeding and hydro-mulching operations, mowing, tacking, 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 169
Soil Retention Blankets

1. DESCRIPTION

Provide and install soil retention blankets (SRB) as shown on the plans or as directed.

2. MATERIALS

Provide only SRB in accordance with DMS-6370, "Soil Retention Blankets," and on the Approved Products List. Use material of the following product type as shown on the plans and provide a copy of the manufacturer's label for the selected product.

Provide an approved wildlife-friendly or spray-on SRB as shown on the plans.

2.1. **Slope Protection Categories**.

2.1.1. **Slope Type**.

2.1.1.1. **Moderate.** Slopes 3:1 or flatter.

2.1.1.2. **Steep.** Slopes steeper than 3:1.

2.1.2. **Soil Type.** Clay or sandy soils as shown on the plans.

2.1.3. **Application Type**. Unless otherwise shown on the plans, use rolled SRB or sprayed SRB.

2.1.4. **Duration**.

2.1.4.1. **Rolled SRB**. Short-term SRB lasting up to 12 mo. and long-term SRB lasting 12 mo. to 35 mo.

2.1.4.2. **Sprayed SRB**. Short-term SRB lasting up to 6 mo. and long-term SRB lasting 6 mo. or more.

2.2. **Channel Protection Categories**.

2.2.1. **Duration.** Temporary or permanent as shown on the plans.

2.2.2. **Shear Stress Condition**. 2, 4, 6, or 8 lb. per square foot as shown on the plans.

3. CONSTRUCTION

Provide a copy of the manufacturer's installation instructions to the Engineer before placement of the material. Place the SRB within 24 hr. after the seeding or sodding operation, or when directed. Install and anchor the SRB in conformance with the manufacturer's published literature. Before placement, mow the area to a maximum height of 4 in. or in conformance with the manufacturer's instructions. Installation includes the repair of ruts, reseeding or resodding, and the removal of rocks, clods, and other foreign materials that may prevent contact of the blanket with the soil.

4. MEASUREMENT

This Item will be measured by the square yard of surface area covered.

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 "Soil Retention Blanket" of the product type shown on the plans. This price is full compensation for equipment, materials, labor, tools, mowing, and incidentals.

Item 192
Landscape Planting

1. DESCRIPTION

Provide and install plants and related materials at designated locations. Transplant plant material, including trees, shrubs, palms, and grasses as shown on the plans. Maintain plants, related materials, and landscaped areas at the specified frequency.

2. MATERIALS

Comply with the following, unless otherwise shown on the plans.

- ANSI Z60.1, "American Standard for Nursery Stock"
- American Joint Committee on Horticultural Nomenclature, *Standardized Plant Names*
- Additional requirements for plants and related materials as shown on the plans.

Use materials in conformance with the following unless otherwise shown on the plans.

2.1. **Plants**. Provide nursery-grown plants unless otherwise shown on the plans. Provide vigorous, healthy, well-rooted plants with well-formed crowns, true to sizes, and of typical shape and characteristics of the species. Provide plants with nametags attached showing the genus, species, and specified variety.

2.1.1. **Rejection of Plants**. Plants with any of the following characteristics are subject to rejection:

- disease or insect infestation, including eggs and larvae;
- dried or damaged root system or crown;
- excessive abrasion of the bark;
- prematurely opened or damaged buds;
- disfiguring knots;
- evidence of heat, freeze, or wind burn, mold, sun scald, or similar conditions;
- damaged, pruned, crooked, or multiple leaders, unless multiple leaders are specified or are normal for the species;
- cut limbs more than 3/4 in. in diameter that have not completely callused;
- dry, soggy, loose, cracked, broken, misshapen, or undersized root balls;
- processed balled roots (bench-balled);
- root balls encased in impervious material;
- overgrown or root-bound plants;
- undersized or unsound containers;
- stock not well established in containers;
- containers with less than 3/4 planting medium depth;
- abnormal balance between height and spread for the species;
- missing or broken serialized locking tags, when specified;
- any condition that is not as shown on the plans or not in conformance with nursery stock standards; or
- conditions that would prevent thriving growth or cause an unacceptable appearance.

2.2. **Backfill and Plant Soil Mix**. Use soil excavated from the plant pits or beds, or provide a loose, friable soil mix as shown on the plans. Provide a soil mix free of reproductive parts of weeds and grasses, harmful substances, and detrimental amounts of foreign matter.

2.3. **Compost**. Use compost in accordance with Section 161.2.3., "General Use Compost (GUC)."

2.4. **Mulch**. Provide loose, organic mulch derived from plants unless other types are shown on the plans. Use mulch free of excessive amounts of leaves, sticks, harmful substances, and detrimental amounts of soil or other foreign matter.

2.5. **Loose Aggregate for Ground Cover.** Furnish loose aggregate using a blend of 1–3-in. local river rock or as shown on the plans.

2.6. **Water**. Use water in accordance with Article 168.2., "Materials."

2.7. **Fertilizer**. Use fertilizer in accordance with Article 166.2., "Materials."

2.8. **Other Materials**. Provide additional incidental materials associated with landscape planting that meet the requirements shown on the plans.

3. CONSTRUCTION

Prevent damage to vegetation, slopes, utilities, structures, and other amenities. Repair any damage within the right of way caused by the Contractor at no additional expense to the Department. Provide and document a licensed pesticide applicator for the treatment of insects, diseases, animals, and vegetation in conformance with the Texas Department of Agriculture (TDA) in the appropriate use category.

3.1. **Plant Inspection Before Delivery**. Plants are subject to inspection at the nursery or location of collection. Provide and use serialized locking tags on plants selected by the Engineer as directed.

3.2. **Plant Delivery**. Notify the Engineer at least 48 hr. before delivering plants to the worksite. Coordinate with the Engineer for inspection and approval of materials upon delivery. Remove rejected plants from the worksite and replace as directed.

3.3. **Mark Plant Locations and Bed Outlines**. Provide and install coded markings, such as wooden stakes, to mark the locations, type of plants, and outline of planting beds. Obtain approval of the plant and bed locations before excavation begins.

3.4. **Transplant Plant Material**. Transplant material using approved mechanical tree spade, or hand dig, as directed. Size rootballs for hand dug material to a diameter of 12 in. per every inch of plant trunk caliper or as directed.

3.5. **Plant Pit Excavation**. Excavate pits for transplant, container, balled and burlapped (B&B), and fabric bag grown stock to the depth shown on the plans or at least the depth of the root ball. Excavate pits for bare root plants equal to the depth of the root system. Excavate pits on slopes using measurements shown on the plans or at least the depth of the root ball based on the uphill side of the pit. Excavate the receiving pits for mechanically transplanted plants with the same type and size of equipment used to dig the plants.

Provide a minimum horizontal dimension of 12 in. between the root ball and pit walls for the following, unless otherwise shown on the plans:

- 15-gal. or larger pots,
- 14-in. or larger boxes, and
- larger than 14-in. root balls of B&B and fabric bag grown plants.

Provide a minimum horizontal dimension of two times the root ball diameter across the pit for the following, unless otherwise shown on the plans:

- less than 15-gal. pots, and
- 14-in. or smaller root balls of B&B and fabric bag grown plants.

Provide a minimum pit diameter for bare root plants that permits the roots to spread without crowding or curving around the walls of the pit.

3.6. **Plant Installation**. Install plants within 24 hr. of excavating plant pits. Install transplant within 1 hr. of transplant excavation. Scarify the walls of pits as plant installation begins. Center all plants in a pit, except those mechanically collected, backfill in lifts, each lift 1/3 of the depth of the root ball, and fill the pit with water after each lift to remove air pockets. Prune protruding roots, from the root ball, for mechanically collected plants, to a point even with the cutting blades. Place the plant in the pit and work sand between the pit walls and the root ball with water until the sand fills all the cavities.

Apply fertilizer as shown on the plans. Ensure that the top of the root ball remains at the grade shown on the plans after final settlement.

3.7. **Plant Basin Construction**. Construct a basin at least 8 in. deep with an inside diameter equal to the pit diameter and with a level top around the plant unless otherwise shown on the plans. Use excavated soil from the plant pits or beds, backfill material, or other approved material for the basin. Spread excess excavated materials over the right of way as directed or remove and dispose of material in conformance with local, state, and federal requirements at locations outside the right of way.

Perform a percolation test as shown on the plans.

3.8. **Watering**. Coordinate the planting work to ensure that an irrigation system, when specified, operates properly to meet the watering requirements. Apply water to plants or planting areas at the rate and frequency specified for an irrigation system or for the application method shown on the plans. Keep the ground and backfill moist at least 12 in. around the entire root ball if a watering rate and frequency are not specified.

3.9. **Using Antitranspirants**. Apply antitranspirants, when shown on the plans, in conformance with the manufacturer's instructions.

3.10. **Pruning**. Accomplish pruning in accordance with ANSI A300 (Part 1) pruning standards. Retain the natural shape of plants according to the species. Limit pruning to removal of dead and broken branches, and an additional amount as specified or directed to improve the appearance and health of plants.

Prune B&B and collected plants to reduce the original crown by approximately 20% by removing interior branches, entangled limbs, and small branches, unless otherwise shown on the plans. Prune to develop the central leader or leaders. Remove and dispose of pruning debris.

Trim, prune, or remove existing tree limbs and brush as shown on the plans and to allow performance of the work in this Item.

Treat exposed cuts in accordance with Item 752, "Tree and Brush Removal."

3.11. **Plant Support**. Install plant supports such as staking, guying, and bracing as shown on the plans. Support and keep plants in a vertical position. Use metal stakes and posts. Use protection guards to avoid damage to the plant.

3.12. **Tree Trunk Protection**. Install tree trunk protection guards when shown on the plans and in conformance with the manufacturer's instructions.

3.13. **Landscape Edge Installation**. Install landscape edging when shown on the plans and in conformance with the manufacturer's instructions.

3.14. **Plant Bed Preparation**. Prepare the bed and install the planting soil mix, soil amendments, vegetation barrier, and other materials as shown on the plans. Amend soil to a depth of 4 in. or as shown on the plans. Blend in 25% GUC measured by volume or as shown on the plans.

3.15. **Mulching**. Mulch plant basins and beds to a depth of 3 in. unless otherwise shown on the plans.

3.16. **Loose Aggregate for Ground Cover**. Install loose aggregate for ground cover to a depth of 4 in. or as shown on the plans. Install a commercial grade vegetation barrier fabric under the aggregate in conformance with manufacturer's instructions. The fabric must be tear- and ultraviolet-resistant.

3.17. **Maintenance**. Begin maintenance of each plant in accordance with this Item when the installation is completed and approved. Perform maintenance until final acceptance of the project, or for at least 90 days should the final acceptance occur less than 90 days after the plant installation is completed and approved, by following the work schedule and frequencies shown on the plans. Perform the minimum requirements in accordance with the following Sections if a work schedule and frequency are not shown on the plans.

3.17.1. **Watering**. Water in accordance with Section 192.3.8., "Watering."

3.17.2. **Mowing, Trimming, and Edging**. Mow, trim, and edge the designated locations. Remove and dispose of litter within the designated areas before mowing, trimming, and edging. Mow, trim, and edge every 15 days during the growing season or as directed, mowing at a 3-in.–4-in. height. Keep cord trimmers at least 1 ft. from plants to prevent damage to the plants. Plants damaged during the maintenance work are subject to rejection and replacement in accordance with Section 192.3.17.9., "Plant Replacement."

3.17.3. **Plant Basin, Bed, and Worksite Maintenance**. Chemically control weeds and unwanted grasses in plant basins, in beds, along and in structures, and around existing plants every 15 days, unless otherwise directed. Reshape plant basins and beds every 30 days as shown on the plans. Maintain mulch in accordance with Section 192.3.15., "Mulching." Ensure that herbicides do not contact desirable plants. Follow the manufacturer's instructions for handling and applying herbicides.

3.17.4. **Plant Supports**. Replace, repair, and adjust supports as shown on the plans and in accordance with Section 192.3.11., "Plant Support." Adjust staking and guying to prevent girdling of plant trunks. Remove or dispose of support material.

3.17.5. **Pruning**. Prune as shown on the plans and in accordance with Section 192.3.10., "Pruning."

3.17.6. **Insect, Disease, and Animal Inspection and Pesticide Treatment**. Inspect plants and planted areas at least every 15 days. Notify the Engineer of concerns and problems and recommend corrective measures in writing for approval. Treat the plants and planted areas in conformance with TDA or Texas Structural Pest Control Board laws and regulations. Follow the manufacturer's instructions for handling and applying pesticides.

3.17.7. **Litter Removal.** Remove litter and debris within the worksite at least every 15 days or as shown on the plans. Dispose of litter from the right of way in accordance with Item 734, "Litter Removal."

3.17.8. **Tree Trunk Protection**. Remove and dispose of tree trunk wrapping material and protection guards as directed.

3.17.9. **Plant Replacement**. Remove and dispose of dead and damaged plants from the worksite as directed. Replace plants as originally specified within 10 days of notification. Plant replacement must be completed and approved before payment is approved when notification is made between the starting date and day 30 of the maintenance work, in accordance with Section 192.5.2., "30-Day Payment." Plant replacement must be completed and approved before payment is approved when notification is made between days 31 and 60 of the maintenance work, in accordance with Section 192.5.3., "60-Day Payment." Plant replacement must be completed and approved before payment is approved when notification is made between days 61 and either the date of project final acceptance or day 90 of the maintenance work, whichever occurs later, in accordance with Section 192.5.4., "Final Payment."

4. MEASUREMENT

This Item will be measured by each plant. When mulch is specified as a separate pay item, it will be measured by the cubic yard or the square yard. When plant soil mix is specified as a separate pay item, it will be measured by the cubic yard. When landscape edge is specified as a separate pay item, it will be measured by the foot. When soil amendment is specified as a separate pay item, it will be measured by the square yard. When loose aggregate for ground cover is specified as a separate pay item, it will be measured by the cubic yard or square yard. When plant bed preparation is specified as a separate pay item, it will be measured by the square yard. When vegetation barrier is specified as a separate pay item, it will be measured by the square yard.

When mulch, plant bed preparation, loose aggregate, soil amendment, and vegetation barrier are specified as separate pay items and measured by the square yard, they are plans quantity measurement Items. 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 "Plant Material" of the size or "Plant Material" of the size and type specified. This price is full compensation for furnishing the plant, compost, fertilizer, mulch, plant soil mix, landscape edge, soil amendment, loose aggregate for ground cover, plant bed preparation, vegetation barrier, and maintenance.

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 "Transplant Plant Material" or "Transplant Plant Material" of the type specified. This price is full compensation to transplant the plant, compost, fertilizer, mulch, plant soil mix, landscape edge, soil amendment, loose aggregate for ground cover, plant bed preparation, and vegetation barrier. Transplant plant materials are not subject to Section 192.3.17., "Maintenance," unless shown on the plans.

When mulch, plant soil mix, landscape edge, soil amendment, loose aggregate for ground cover, plant bed preparation, and vegetation barrier are specified as separate on the plans to be pay items, 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 "Mulch" or "Mulch" of the type specified, "Plant Soil Mix" or "Plant Soil Mix" of the type specified, "Landscape Edge" or "Landscape Edge" of the type specified, "Soil Amendment" or "Soil Amendment" of the type specified, "Loose Aggregate for Ground Cover" of the type specified, "Plant Bed Preparation" or "Plant Bed Preparation" of the type specified, and "Vegetation Barrier" or "Vegetation Barrier" of the type specified. The price is full compensation for materials, equipment, labor, tools, and incidentals.

Payment for "Plant Material" will be addressed in the following manner.

5.1. **Initial Payment**. When the planting and installation of related materials are completed and approved, 70% of the unit price bid for each related plant will be paid.

5.2. **30-Day Payment**. When the first 30 days of the plant maintenance (in accordance with Section 192.3.17., "Maintenance") are completed and approved, an additional 10% of the unit price bid for each related plant will be paid, but if the maintenance is not completed and approved, this portion of the payment will be forfeited.

5.3. **60-Day Payment**. When the second 30 days of the plant maintenance are completed and approved, an additional 10% of the unit price bid for each related plant will be paid, but if the maintenance is not completed and approved, this portion of the payment will be forfeited.

5.4. **Final Payment**. After the final inspection and acceptance of the project or the completion of the 90-day maintenance, whichever occurs later, an additional 10% of the unit price bid for all plants will be paid, but if the maintenance is not completed and approved, this portion of the payment will be forfeited.

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 (ton)	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 ton 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 125–550 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:

- two metal tamping drums, rolls, or shells, each with a 60-in. minimum diameter and a 5-ft. minimum width; or
- one rear and two forward drums, each with a 60-in. minimum diameter. Arrange drums so that the rear drum compacts the space between the two 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 7–21 sq. in.,
- are self-cleaning,
- exert a static load of at least 550 psi, and
- are spaced at 1 tamping foot per 0.65–0.70 sq. ft. 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 can:

- 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 ton and a vibratory drum.

2.3.2. **Drum (Type B)**. Furnish a roller with a minimum static weight of 6 ton 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 using 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 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 nine pneumatic tires,
- with an effective rolling width of approximately 5 ft.,
- capable of providing a total uniform load of 4.5–9 ton, 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 seven pneumatic tires,
- with an effective rolling width of approximately 7 ft.,
- capable of providing a total uniform load of 12–25 ton, 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 four pneumatic-tired wheels mounted on axles carrying no more than two 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 ton,
- 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 two 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 5–13 ton 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 conformance with the applicable Items using equipment and roller speeds shown 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 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 250
Geogrid Base Reinforcement

1. DESCRIPTION

Use geogrid to reinforce flexible base placed on embankment material. Geogrid consists of a synthetic planar structure formed by a regular network of integrally connected polymeric tensile elements with apertures designed to interlock with the base and the underlying material.

2. MATERIALS

Furnish geogrid of the type shown on the plans meeting the requirements of DMS-6240, "Geogrid for Base/Embankment Reinforcement." When directed, randomly select a roll from those delivered to the project and sample a piece of geogrid from the roll in accordance with Tex-735-I. Do not sample from an area of the roll that is damaged or distorted. The Engineer must witness the sampling. The Materials and Tests Division (MTD) will test the geogrid sample to determine whether it meets the material requirements of DMS-6240.

When test results fail to meet any of the minimum requirements, the Engineer may reject the roll and may randomly select an additional roll to sample and test. If the additional sample fails to meet any of the material requirements, the Engineer may reject the entire quantity of rolls represented by the samples tested.

2.1. **Packaging**. Package geogrid in rolls of the length and width shown on the plans or as approved. Package each roll in one continuous piece in a suitable sheath, wrapper, or container to protect the geogrid from damage due to ultraviolet light, moisture, storage, and handling.

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

- manufacturer's roll number,
- manufacturer's lot or control number,
- name of manufacturer and supplier,
- style or catalog description of product, and
- roll width and length.

3. CONSTRUCTION

Install geogrid in accordance with the lines and grades as shown on the plans. Do not operate tracked construction equipment on the geogrid until a minimum cover of 6 in. of flexible base backfill material is placed on the geogrid. Install the geogrid to avoid any deformation or damage to the underlying, compacted material below the geogrid. When the underlying, compacted material below the geogrid is damaged during installation, correct all areas to the satisfaction of the Engineer.

3.1. **Geogrid Placement**. Orient the geogrid length as unrolled parallel to the direction of roadway. Overlap geogrid sections as shown on the plans or as directed. Use plastic zip-ties at overlap joints or as directed. When placing geogrid around corners, cutting and diagonal lapping may be required. Pin geogrid at the beginning of the backfill section as directed. Keep the geogrid taut and flat throughout backfilling, but not restrained from stretching or flattening. Use a track loader to place the flexible base material by cascading it onto the geogrid to a minimum depth of 6 in. Spread, shape, and use ordinary compaction to compact the flexible base material into a uniform layer.

Avoid direct contact by equipment with the geogrid. When approved, rubber-tired equipment may be operated directly on the geogrid. When approved, operate the rubber-tired equipment at a maximum of

5 mph, do not turn tires on the geogrid, do not make sudden stops and starts on the geogrid, and do not distort the geogrid to create excessive deformation waves. Correct areas with distorted and excessive deformation waves to the satisfaction of the Engineer. When directed by the Engineer, adjust the geogrid installation and construction methods to minimize any distortion and deformation waves.

3.1.1. **Longitudinal Joints**. Overlap longitudinal joints by a minimum of 1 ft. Space longitudinal zip-ties 10–20 ft. or as directed.

3.1.2. **Transverse Joints**. Overlap transverse joints by a minimum of 1 ft. Space transverse zip-ties 4–5 ft. or as directed.

3.2. **Damage Repair**. Remove and replace Contractor-damaged or excessively deformed areas as directed at no additional cost to the Department. Lap repair areas a minimum of 3 ft. in all directions. Tie each side of repair grid in at least three locations, but do not exceed normal construction spacing. The tie spacing for odd shapes will be as directed. Repair excessively deformed materials underlying the grid as directed.

4. MEASUREMENT

Geogrid base reinforcement will be measured by the square yard of roadway placement as shown on the plans with no allowance for overlapping at transverse and longitudinal joints.

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 bid price for "Geogrid Base Reinforcement" of the type specified. This price is full compensation for furnishing, preparing, hauling, and placing materials, including labor, materials, freight, tools, equipment, and incidentals.

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 400

Excavation and Backfill for Structures

1. DESCRIPTION

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

2. MATERIALS

Use materials that meet the requirements of the following Items.

- Item 401, "Flowable Backfill,"
- Item 421, "Hydraulic Cement Concrete," and
- DMS-4600, "Hydraulic Cement."

3. CONSTRUCTION

3.1. **Excavation**.

3.1.1. **General**. Excavate to the lines and grades shown on the plans or as directed. Provide slopes, benching, sheeting, bracing, pumping, and bailing as necessary to maintain the stability and safety of excavations up to 5 ft. deep. Excavation protection for excavations deeper than 5 ft. are governed by Item 402, "Trench Excavation Protection," and Item 403, "Temporary Special Shoring." Use satisfactory excavated material as backfill or as embankment fill in accordance with Item 132, "Embankment." Dispose of material not incorporated into the final project off the right of way in accordance with federal, state, and local regulations.

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

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

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

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

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

3.1.1.3. **Utilities**. Comply with the requirements of Article 7.15., "Responsibility for Damage Claims." Conduct work with minimum disturbance of existing utilities, and coordinate work in or near utilities with the utility owners. Inform utility owners before work begins, allowing them enough time to identify, locate, reroute, or make other adjustments to utility lines.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

B_c – Outside diameter or horizontal dimension

D – Inside diameter of pipe

d – Min. bedding material below pipe

D	d
≤ 27"	3"
30" to 60"	4"
≥ 66"	6"

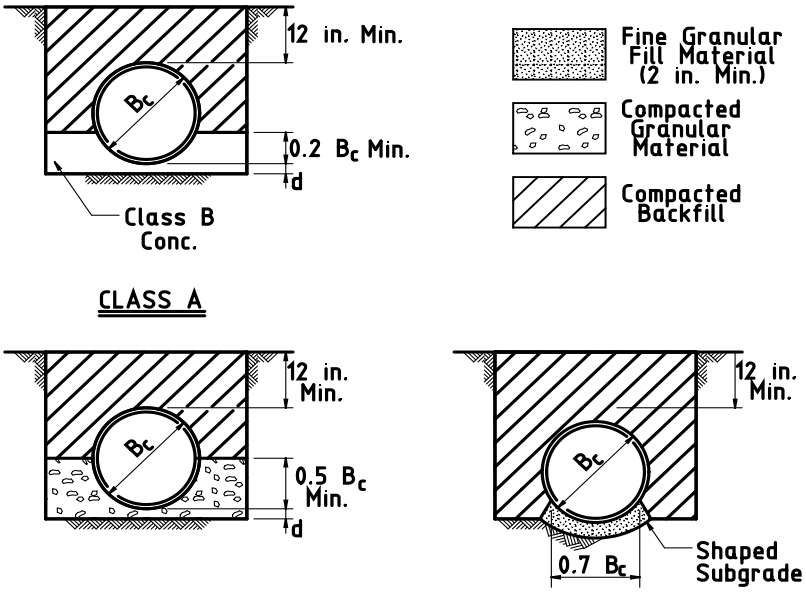


Figure 1
Bedding Diagrams

3.3. **Backfill**.

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

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

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

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

Table 1
Cohesionless Material Gradation Limits

Sieve Size	Percent Retained
3"	0
#10	Note 1
#200	90–100

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

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

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

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

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

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

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

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

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

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

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

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

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

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

4. MEASUREMENT

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

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

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

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

4.1.1. **Boundaries of Measurement**.

4.1.1.1. **Pipe**.

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

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

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

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

4.1.1.3. **Footings, Walls, Boxes, and Other Excavation**. No material outside of vertical planes 1 ft. beyond and parallel to the edges of the footings or outside walls will be included whether or not a cofferdam or shoring is

used. When plans provide the option of cast-in-place or precast boxes, measurement will be based on the cast-in-place option.

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

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

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

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

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

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

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

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

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

5. PAYMENT

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

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

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

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

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

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

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

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

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

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

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

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

Table 2
Payment for Required Overexcavation

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

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

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

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

The unit prices bid are full compensation for excavation including removing obstructions and plugging drainage systems; bedding and backfilling including placing, sprinkling and compaction of material; soundings; cleaning and filling seams; constructing and removing cofferdams; de-watering, sheeting, or bracing excavations up to and including 5 ft. deep; pumps; drills; explosives; disposition of surplus material; cutting pavement and base to neat lines; and materials, hauling, equipment, labor, tools, and incidentals.

Flowable backfill will be paid for as provided in Item 401, "Flowable Backfill." Protection methods for open excavations deeper than 5 ft. will be measured and paid for as required under Item 402, "Trench Excavation Protection," or Item 403, "Temporary Special Shoring."

Item 401
Flowable Backfill

1. DESCRIPTION

Furnish and place flowable backfill for trench, hole, or other void.

2. MATERIALS

Use materials from prequalified sources listed on the Department website. Use materials from non-listed sources only when tested and approved before use. Allow 30 calendar days for the Engineer to sample, test, and report results for non-listed sources. Do not combine approved material with unapproved material.

1.1 **Cement**. Furnish cement in accordance with DMS-4600, "Hydraulic Cement."

2.2 **Fly Ash**. Furnish fly ash in accordance with DMS-4610, "Fly Ash."

2.3 **Chemical Admixtures**. Furnish chemical admixtures in accordance with DMS-4640, "Chemical Admixtures for Concrete." Use specialty type admixtures to enhance the flowability, reduce shrinkage, and reduce segregation by maintaining solids in suspension when necessary. Use and proportion all admixtures in accordance with the manufacturer's recommendations.

2.4 **Fine Aggregate**. Provide fine aggregate that will stay in suspension in the mortar to the extent required for proper flow and that meets the gradation requirements of Table 1.

Table 1
Aggregate Gradation Chart

Sieve Size	Percent Passing
3/4"	100
#200	0–30

Test fine aggregate gradation in accordance with Tex-401-A.

Plasticity Index (PI) must not exceed 6 when tested in accordance with Tex-106-E.

1.5 **Mixing Water**. Use mixing water in accordance with Item 421, "Hydraulic Cement Concrete."

3. CONSTRUCTION

Submit a construction method and plan, including mix design, for approval. Provide a means of filling the entire void area, and be able to demonstrate this has been accomplished. Prevent the movement of any inserted structure from its designated location. Remove and replace or correct the problem if voids are found in the fill or any of the requirements are not met as shown on the plans without additional cost to the Department.

Furnish a mix meeting the requirements of Table 2 unless otherwise shown on the plans.

Table 2
Flowable Fill Mix Design Requirements

Property	Excavatable	Non-Excavatable	Test Method
28-day Compressive Strength,[1] psi	80 to 200	> 200	ASTM D4832
Consistency,[2] Min diameter, in.	8		ASTM D6103
Unit Weight, pcf	90 to 125	100 to 145	ASTM D6023
Air Content, %	10 to 30	5 to 15	ASTM D6023

1. Average of 2 specimens.
2. Mixture must not segregate.

Mix the flowable fill using a central-mixed concrete plant, ready-mix concrete truck, pug mill, or other approved method.

Furnish all labor, equipment, tools, containers, and molds required for sampling, making, transporting, curing, removal, and disposal of test specimens. Furnish test molds meeting the requirements of Tex-447-A. Transport, strip, and cure the test specimens as scheduled at the designated location. Cure test specimens in accordance with Tex-447-A. The Engineer will sample, make, and test all specimens. Dispose of used, broken specimens in an approved location and manner. The frequency of job-control testing will be at the direction of the Engineer.

4. MEASUREMENT

This Item will be measured by the cubic yard of material placed. Measurement will not include additional volume caused by slips, slides, or cave-ins resulting from the Contractor's operations.

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 "Flowable Backfill." This price is full compensation for furnishing, hauling, and placing materials and for equipment, tools, labor, and incidentals.

Item 403
Temporary Special Shoring

1. DESCRIPTION

Furnish and install temporary shoring to hold the surrounding earth, water, or both out of the work area.

2. MATERIALS

Furnish new or used materials. Furnish materials that meet the requirements of Item 410, "Soil Nail Anchors," or Item 411, "Rock Nail Anchors," when using temporary nailed walls (rock or soil).

3. CONSTRUCTION

The Contractor is responsible for the temporary special shoring design unless complete details are shown on the plans. Submit details and design calculations bearing the seal and signature of a licensed professional engineer before constructing the shoring. The Department reserves the right to reject designs. Design the shoring to comply with OSHA Standards and Interpretations, 29 CFR Part 1926, Subpart P, "Excavations." Design structural systems to comply with AASHTO *Standard Specifications for Highway Bridges* or AASHTO LRFD *Bridge Design Specifications*. Design shoring subject to railroad loading to comply with the AREMA *Manual for Railway Engineering* and any additional requirements of the railway being supported.

Provide vertical or sloped cuts, benches, shields, support systems, or other systems to provide the necessary protection in accordance with the approved design. Construct temporary nailed walls (rock or soil), when used, in accordance with Item 410 or Item 411.

4. MEASUREMENT

This Item will be measured by the square foot of surface area of a vertical plane at the face of the shoring between the top of the ground being supported and the minimum protection grade line shown on the plans. If no minimum protection grade is shown on the plans, the lowest required excavated elevation will be used. Shoring projecting above the level of the ground being supported will not be measured. When excavation techniques (e.g., sloped cuts or benching) are used to provide the necessary protection, the surface area for payment will be calculated based on the area described by a vertical plane adjacent to the 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 unit price bid for "Temporary Special Shoring." This price is full compensation for excavation and backfill; furnishing, placing, and removing shoring, sheeting, or bracing; de-watering or diversion of water; jacking and jack removal; and equipment, labor, materials, tools, and incidentals.

No payment will be made for special shoring made necessary by the selection of an optional design or sequence of work that creates the need for shoring.

Item 416
Drilled Shaft Foundations

1. DESCRIPTION

Construct foundations consisting of reinforced or non-reinforced concrete drilled shafts.

2. MATERIALS

Use materials that meet the requirements of the following Items.

- Item 421, "Hydraulic Cement Concrete,"
- Item 440, "Reinforcement for Concrete," and
- Item 448, "Structural Field Welding."

Use concrete for drilled shafts that meets the requirements of Table 1 unless otherwise shown on the plans.

Table 1
Concrete for Drilled Shafts

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

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

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

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

Table 2
Slump Requirements

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

Perform a slump loss test in accordance with Tex-430-A before beginning work when casing is to be pulled or concrete is to be placed underwater or under slurry. Provide concrete that will maintain a slump of at least 4 in. throughout the entire anticipated time of concrete placement. Time of concrete placement is described in Section 416.3.6., "Concrete," and Section 416.3.7., "Additional Requirements for Slurry Displacement or Underwater Concrete Placement Methods." Note the temperature of the concrete mix at the beginning of the slump loss test. Place the concrete if its temperature at the time of placement into the drilled shaft is no more than 10°F higher than the slump loss test temperature. Use ice or other concrete cooling ingredients to lower concrete temperature, or run additional slump loss tests at the higher temperatures. Slump loss testing will be waived if anticipated time of concrete placement is less than 90 minutes.

Use mineral drilling slurry that meets the requirements of Table 3, as determined by Tex-130-E. Determine pH of slurry by Tex-128-E or pH paper strips.

Table 3
Mineral Slurry Requirements

Before Introduction into the Excavation			Sampled from the Bottom of the Excavation before Concreting		
Specific Gravity	Sand Content	pH	Specific Gravity	Viscosity (sec.)	Sand Content
≤ 1.10	≤ 1%	8–11	≤ 1.15	≤ 45	≤ 4%

Use mineral slurry consisting of processed bentonite or attapulgite clays mixed with clean fresh water. Do not use partially hydrolyzed polyacrylamide (PHPA) polymeric slurry or any blended mineral-polymer slurry.

If approved, water may be used as the drilling fluid. In this case, all of the provisions of Table 3 must be met except that the maximum specific gravity is not to exceed 1.12.

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

3. CONSTRUCTION

Submit Drilled Shaft installation plan for review no later than one month before drilled shaft construction. Include the following in the plan:

- Name and experience record of the drilled shaft superintendent who will be in charge of drilled shaft operations for this project.
- List of proposed equipment to be used, including cranes, drills, augers, bailing buckets, final cleaning equipment, desanding equipment, slurry pumps, core sampling equipment, tremies or concrete pumps, casing, etc.
- Details of overall construction operation sequence and the sequence of shaft construction in bents or groups.
- Details of shaft excavation methods.
- When the use of slurry is anticipated, details of the slurry mix design and its suitability for the subsurface conditions at the construction site, mixing and storage methods, maintenance methods and disposal procedures.
- Details of methods to clean the shaft excavation.
- Details of reinforcement placement, including support and centralization methods.
- Details of concrete placement, including proposed operational procedures for free fall, tremie or pumping methods.
- Details of casing installation and removal methods.

The installation plan will be reviewed for conformance with the plans, specifications and special provisions. The Contractor will be notified within 14 days of receipt of the installation plan of any additional information required and/or changes necessary to meet the contract requirements. All procedural approvals given will be subject to trial in the field and will not relieve the Contractor of the responsibility to satisfactorily complete the work as detailed in the plans and specifications.

Place the shaft to within the following tolerances:

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

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

3.1. **Excavation**. The plans indicate the expected depths and elevations for encountering satisfactory bearing material. Excavate as required for the shafts through all materials encountered to the dimensions and elevations shown on the plans or required by the site conditions. Removal of man-made obstructions not shown on the plans will be paid for in accordance with Article 9.7., "Payment for Extra Work and Force Account Method." Adjust the bottom of the shaft or alter the foundation if satisfactory founding material is not encountered at plan elevation, as approved to satisfactorily comply with design requirements. Blasting is not allowed for excavations.

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

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

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

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

3.2. **Core Holes**. Take cores to determine the character of the supporting materials if directed. Use a method that will result in recovery of an intact sample adequate for judging the character of the founding material. Such cores should be at least 5 ft. deeper than the proposed founding grade or a depth equal to the diameter of the shaft, whichever is greater. Take these cores when the excavation is complete.

3.3. **Casing**. Use casing when necessary to prevent caving of the material, to exclude ground water, when slurry is used for hole stabilization, or when required as part of the Contractor's Safety Plan. Provide casing with an outside diameter not less than the specified diameter of the shaft. The portion of shaft below the casing may be as much as 2 in. smaller than the specified shaft diameter. No extra compensation will be made for concrete required to fill an oversized casing or oversized excavation. Use casing strong enough to withstand handling stresses and pressures of concrete and of the surrounding earth or water, and that is watertight, smooth, clean, and free of accumulations of hardened concrete.

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

Leave casing in place only if authorized or shown on the plans. Extract casing only after placing the concrete to an appropriate level. Maintain sufficient concrete in the casing at all times to counteract soil and water pressure. Rotate or move the casing up or down a few inches if necessary before and during concrete placement to facilitate extraction of the casing.

3.4. **Requirements for Slurry Displacement Method**. When soil conditions warrant, use the slurry displacement method to construct drilled shafts unless otherwise shown on the plans. Use this method to support the sides of the excavation with processed mineral slurry that is then displaced by concrete to form a continuous concrete shaft.

Install surface casing to a minimum of 10 ft. below existing ground before introducing slurry. Do not use casing other than surface casing. Do not use surface casing longer than 20 ft. without approval. Do not extract the surface casing until after placing the concrete.

Pre-mix slurry in a reservoir with enough capacity to fill the excavation and for recovery of the slurry during concrete placement. Do not mix slurry in the shaft excavation or other hole. Allow adequate time for hydration of the slurry before introduction into the excavation.

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

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

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

Agitate the congealed slurry to liquefaction if the slurry forms a gel before concrete placement, and whenever directed.

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

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

Extend the reinforcing steel cage as follows if the shaft is lengthened beyond plan length unless directed otherwise.

- Extend the cage to the bottom for shafts supporting structures other than bridges.
- Extend the cage to 25 ft. or to the bottom, whichever is shorter, for bridge shafts with plan lengths less than 25 ft.
- Do not extend the cage for bridge shafts with plan lengths at least 25 ft. that are lengthened less than 33% of plan length.
- Extend the cage as directed for bridge shafts with plan lengths at least 25 ft. that are lengthened more than 33% of plan length.

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

Tie spiral reinforcement to the longitudinal bars at a spacing no more than 24 in., or as required for a stable cage. Ensure lateral reinforcement is not welded to longitudinal bars unless otherwise shown on the plans.

Center the reinforcing steel cage in the excavation using approved "roller" type centering devices unless otherwise approved. Use concrete or plastic chairs to keep the reinforcing cage off of the bottom of the hole. Use centering devices starting at 1.5 ft. off from the bottom of the cage and spaced vertically at intervals not exceeding 10 ft. Use a minimum of 3 centering devices per level at a spacing not to exceed 30 in. Flat or crescent-shaped centralizers ("sleds") are not allowed.

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

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

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

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

3.6. **Concrete**. Perform all work in accordance with Item 420, "Concrete Substructures." Provide concrete with maximum placement temperatures as specified in Table 4. Provide thermal analysis to show and temperature recording devices to verify maximum core temperature requirements are met as specified in Section 420.4.7.14., "Mass Placements," as directed.

Table 4
Maximum Concrete Placing Temperature

Shaft Size	Mix Design Options 1–5	Mix Design Options 6–8
Diameter < 5 ft.	95°F	95°F
5 ft.≤ Diameter ≤ 7 ft.	95°F	85°F
7 ft. < Diameter	85°F	75°F

Form portions of drilled shaft that project above natural ground.

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

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

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

Maintain a sufficient head of concrete for cased shafts at all times above the bottom of the casing to overcome hydrostatic pressure. Extract casing at a slow, uniform rate with the pull in line with the axis of the shaft. Monitor the concrete level in the casing during extraction. Stop the extraction and add concrete to the casing as required to ensure a completely full hole upon casing removal. The elapsed time from the mixing of the first concrete placed into the cased portion of the shaft until the completion of extraction of the casing must not exceed the time for which the concrete maintains a slump of over 4 in. in accordance with Article 416.2., "Materials." Modify the concrete mix, the construction procedures, or both for subsequent shafts if the elapsed time is exceeded.

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

3.7. **Additional Requirements for Slurry Displacement or Underwater Concrete Placement Methods**. Place concrete on the same day the shaft is excavated and as soon as possible after all excavation is complete and reinforcing steel is placed. Use an air lift or cleanout bucket of the proper size to clean the bottom of the excavation before placing the reinforcing steel cage and concrete. Place concrete through a closed tremie or pump it to the bottom of the excavation. The minimum tremie diameter will be at least 6 times the maximum size of aggregate used in the concrete mix but not less than 10 in. Initially seal the tremie or pump line to positively separate the concrete from the slurry or water. Place concrete continuously from the beginning of placement until the shaft is completed. Keep the tremie full of concrete and well submerged in the previously placed concrete at all times if using a tremie. Raise the tremie as necessary to maintain the free flow of concrete and the stability of any casing used. Keep the discharge tube submerged in the previously placed concrete at all times if using a pump. Place additional concrete to ensure the removal of any contaminated concrete at the top of the shaft. Allow the top portion of concrete to flush completely from the hole at the completion of the pour until there is no evidence of slurry or water contamination. Do not attempt to remove this concrete with shovels, pumps, or other means. Level the top of shaft with hand tools as necessary.

Use a sump or other approved method to channel displaced fluid and concrete away from the shaft excavation. Recover slurry and dispose of it as approved. Do not discharge displaced fluids into or near

streams or other bodies of water. Provide a collar or other means of capturing slurry and the top portion of concrete flushed from the shaft for pours over water.

Remove the tube, reseal it at the bottom, penetrate with the tube into the concrete already placed by at least 5 ft., and recharge it before continuing if concrete placement is interrupted due to withdrawal of the submerged end of the tremie or pump discharge tube before completion. If this condition exists, notify the Engineer and note the elevation and circumstances related to the loss of seal on the drilled shaft log.

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

3.8. **Test Load**. Load test shafts, if required, in accordance with Item 405, "Foundation Load Test."

3.9. **Trial Shaft**. When required on the plans, construct trial shafts to the depth and diameter specified on the plans. Trial shafts include: drilling the hole, placement of the rebar cage (unless otherwise stated), and placement of the concrete. When trial shafts are required, delay start of production shafts until successful completion of trial shafts.

4. MEASUREMENT

4.1. **Drilled Shaft**. Drilled shaft foundations will be measured by the foot to the bottom of the shaft.

4.1.1. **Interior Bents and Piers**. Shafts will be measured from a point approximately 6 in. below the finished earthwork elevation at the center of each shaft, unless specific elevations or dimensions are indicated on the plans or unless otherwise directed to meet unusual conditions. The bent height shown on the plans is for estimating purposes only and does not control the top-of-shaft measurement.

4.1.2. **Abutment Bents and Retaining Walls**. Shafts will be measured from the bottom of footing or cap elevation.

4.1.3. **Other Non-Bridge Structures**. Shafts, including trial shafts, will be measured from the top of the shaft.

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

5. PAYMENT

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

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

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

5.1. **Drilled Shaft**. The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Drilled Shaft," "Drilled Shaft (Non-reinforced)," "Drilled Shaft (Sign Mounts)," "Drilled Shaft (High Mast Pole)," "Drilled Shaft (Roadway Illumination Pole)," or "Drilled Shaft (Traffic Signal Pole)" of the specified diameter, subject to the limitations for overruns authorized by the Engineer given in Section 416.5.1.1., "Overrun."

5.1.1. **Overrun**. Payment for individual completed shaft lengths up to and including 5 ft. in excess of the maximum plan length shaft, as defined in Section 416.5.1.2., "Maximum Plan Length Shaft," will be made at the unit price bid per foot of the specified diameter.

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

Payment for the portion of individual completed shaft length in excess of 15 ft. more than the maximum plan length shaft, as defined in Section 416.5.1.2., "Maximum Plan Length Shaft," will be made at a unit price equal to 125% of the unit price bid per foot of the specified diameter.

5.1.2. **Maximum Plan Length Shaft**. Payment described above is subject to the following provisions for extra depth drilling:

- For bridge structures, the maximum plan length shaft is the maximum length shaft, regardless of diameter, for any drilled shaft on that specific bridge.
- For retaining walls, the maximum plan length shaft is the maximum length shaft, regardless of diameter, for any drilled shaft on that specific retaining wall.
- For overhead sign structures, the maximum plan length shaft is the maximum length shaft, regardless of diameter, for any overhead sign structures included in the Contract.
- For high mast illumination poles, the maximum plan length shaft is the maximum length shaft, regardless of diameter, for any high mast illumination pole included in the Contract.
- For roadway illumination poles, the maximum plan length shaft is the maximum length shaft, regardless of diameter, for any roadway illumination pole included in the Contract.
- For traffic signal poles, the maximum plan length shaft is the maximum length shaft, regardless of diameter, for any traffic signal pole included in the Contract.

5.2. **Core Hole**. Core holes will be paid at $200 each.

Item 420
Concrete Substructures

1. DESCRIPTION

Construct concrete substructures including footings, columns, caps, abutments, piers, culverts, other bridge substructure elements, and other concrete structures as indicated.

2. MATERIALS

2.1. **Concrete**. Provide concrete in accordance with Item 421, "Hydraulic Cement Concrete." Provide the class of concrete for each type of structure or unit as shown on the plans or in pertinent governing specifications.

2.2. **Grout or Mortar**. Provide grout for dowelling anchors or precast connections in accordance with DMS-4675, "Cementitious Grouts and Mortars for Miscellaneous Applications."

2.3. **Latex Curing Materials**. Provide an acrylic-polymer latex admixture (acrylic resin emulsion per DMS-4640, "Chemical Admixtures for Concrete") suitable for producing polymer-modified concrete or mortar. Do not allow latex to freeze.

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

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

- Provide preformed fiber expansion joint material that conforms to the dimensions shown on the plans.
- Provide preformed bituminous fiber material unless otherwise specified.
- Provide asphalt board that conforms to dimensions shown on the plans.
- Provide re-bonded neoprene filler that conforms to the dimensions shown on the plans.

2.6. **Waterstop**. Provide rubber or polyvinyl chloride (PVC) waterstops in accordance with DMS-6160, "Water Stops, Nylon Reinforced Neoprene Sheet, and Elastomeric Pads," unless otherwise shown on the plans.

2.7. **Curing Materials**. Provide membrane curing compounds in accordance with DMS-4650, "Hydraulic Cement Concrete Curing Materials and Evaporation Retardants."

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

Provide polyethylene sheeting that is at least 4 mils thick and free from visible defects. Provide only clear or opaque white sheeting when the ambient temperature during curing exceeds 90°F or when applicable to control temperature during mass pours.

Provide burlap-polyethylene mats made from burlap impregnated on 1 side with a film of opaque white pigmented polyethylene, free from visible defects. Provide laminated mats that have at least 1 layer of an impervious material such as polyethylene, vinyl plastic, or other acceptable material (either as a solid sheet or impregnated into another fabric) and are free of visible defects.

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

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

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

2.8. **Epoxy**. Provide epoxy materials in accordance with DMS-6100, "Epoxies and Adhesives," unless otherwise specified.

3. EQUIPMENT

3.1. **Transporting and Placing Equipment**. Use appropriate transporting and placing equipment such as buckets, chutes, buggies, belt conveyors, pumps, or other equipment as necessary. Ensure concrete is not transported or conveyed through equipment made of aluminum.

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

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

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

3.3. **Temperature Recording Equipment**. Use strip chart temperature recording devices, recording maturity meters in accordance with Tex-426-A, or other approved devices that are accurate to within ±2°F within the range of 32°F to 212°F for mass concrete operations, cold weather placements, and as otherwise specified.

3.4. **Artificial Heating Equipment**. Use artificial heating equipment as necessary for maintaining the concrete temperatures as specified in Section 420.4.7.11., "Placing Concrete in Cold Weather."

3.5. **Spraying Equipment**. Use mechanically powered pressure sprayers, either air or airless, with appropriate atomizing nozzles for the application of membrane curing. Use hand-pressurized spray equipment with 2 or 3 fan-spray nozzles if approved. Ensure the spray from each nozzle overlaps the spray from adjacent nozzles by approximately 50%.

3.6. **Concrete Testing Equipment**. Provide testing equipment for use by the Engineer in accordance with Section 421.3.3., "Testing Equipment."

4. CONSTRUCTION

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

Unless otherwise shown on the plans, it is the Contractor's option to perform testing on structural concrete (structural classes of concrete are identified in Table 8 of Section 421.4.1., "Classification of Concrete Mix Designs,") to determine the in-situ strength to address the schedule restrictions in Section 420.4.1., "Schedule Restrictions." The Engineer may require the Contractor to perform this testing for concrete placed in cold weather. Make enough test specimens for Contractor-performed testing to ensure strength requirements are met for the operations listed in Section 420.4.1., "Schedule Restrictions." Make at least

1 set of test specimens for each element cast each day. Cure these specimens under the same conditions as the portion of the structure involved for all stages of construction. Ensure safe handling, curing, and storage of all test specimens. Provide testing personnel, and sample and test the hardened concrete in accordance with Section 421.4.8., "Sampling and Testing of Concrete." The maturity method, Tex-426-A, may be used for in-situ strength determination for schedule restrictions if approved. Coring will not be allowed for in-situ strength determination for schedule restrictions. Provide the Engineer the opportunity to witness all testing operations. Report all test results to the Engineer.

If the Contractor does not wish to perform schedule restriction testing, the Engineer's 7-day lab-cured tests, performed in accordance with Article 421.5., "Acceptance of Concrete," will be used for schedule restriction determinations. The Engineer may require additional time for strength gain to account for field curing conditions such as cold weather.

4.1. **Schedule Restrictions**. Construct and open completed structures to traffic with the following limitations unless otherwise shown on the plans:

4.1.1. **Setting Forms**. Attain at least 2,500 psi compressive strength before erecting forms on concrete footings supported by piling or drilled shafts, or on individual drilled shafts. Erect forms on spread footings and culvert footings after the footing concrete has aged at least 2 curing days as defined in Section 420.4.10., "Curing Concrete." Place concrete only after the forms and reinforcing steel have been inspected by the Engineer.

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

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

4.1.2. **Removal of Forms and Falsework**. Keep in place weight-supporting forms and falsework for bridge components and culvert slabs until the concrete has attained a compressive strength of 2,500 psi in accordance with Section 420.4.11., "Removal of Forms and Falsework." Keep all forms for mass placements in place for 4 days following concrete placement unless otherwise approved based on the outcome of the heat control plan outlined in Section 420.4.7.14., "Mass Placements."

4.1.3. **Placement of Superstructure Members**. Erect or place superstructure members or precast substructure members only after the substructure concrete has attained a compressive strength of 3,000 psi.

4.1.4. **Opening to Traffic**. Direct traffic culverts may be opened to construction traffic when the design strength specified in Section 421.4.1., "Classification of Concrete Mix Design," has been attained if curing is maintained. Obtain approval before opening direct traffic culverts to the traveling public. Open other noncritical structural and nonstructural concrete for service upon the completion of curing unless otherwise specified or directed.

4.1.5. **Post-Tensioned Construction**. Ensure strength requirements on the plans for structural elements designed to be post-tensioned are met for stressing and staged loading of structural elements.

4.1.6. **Backfilling**. Backfill in accordance with Section 400.3.3., "Backfill."

4.2. **Plans for Falsework and Forms**. Submit plans for falsework and forms for the following items: vertical forms for piers and single column bents; load supporting forms for caps and tie-beams; form attachments for bridges to be widened; and other items as indicated or directed. Provide design calculations when requested. Show all essential details of proposed forms, falsework, and bracing. Have a licensed professional engineer design, seal, and sign these plans. Department approval is not required, except as noted in Table 1 of Item 5, "Control of the Work," when forms or falsework are located such that public safety can be affected, but the Department reserves the right to request modifications to the plans. The Contractor is responsible for the adequacy of these plans. Design job-fabricated formwork assuming a weight of 150 pcf for concrete, and

include a liveload allowance of 50 psf of horizontal surface of the form. Do not exceed 125% of the allowable stresses used by the Department for the design of structures.

4.3. **Falsework**. Design and construct falsework to safely carry the maximum anticipated loads, including wind loads, and to provide the necessary rigidity. Consult AASHTO's *Guide Design Specifications for Bridge Temporary Works* and *Construction Handbook for Bridge Temporary Works* for falsework and shoring information not indicated below. Submit details in accordance with Section 420.4.2., "Plans for Falsework and Forms."

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

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

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

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

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

Place falsework that cannot be founded on a satisfactory spread footing on piling or drilled shafts with enough bearing capacity to support the superimposed load without settlement. Drive falsework piling to the required resistance determined by the applicable formula in Item 404, "Driving Piling." Design drilled shafts for falsework to carry the superimposed load using both skin friction and point bearing.

Weld in conformance with Item 448, "Structural Field Welding." Securely brace each falsework bent to provide the stiffness required, and securely fasten the bracing to each pile or column it crosses.

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

4.4. **Forms**. Submit formwork plans in accordance with Section 420.4.2., "Plans for Falsework and Forms."

4.4.1. **General**. Provide forms of either timber or metal except where otherwise specified or permitted.

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

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

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

Provide commercial form liners for imprinting a pattern or texture on the concrete surface as shown on the plans and specified in Section 427.4.3.5., “Form Liner Finish.”

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

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

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

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

Complete all preparatory work before requesting permission to place concrete.

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

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

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

Provide form lining for all formed surfaces except:

- the inside of culvert barrels, inlets, manholes, and box girders;
- surfaces that are subsequently covered by backfill material or are completely enclosed; and
- any surface formed by a single finished board or by plywood.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

4.6. **Placing Reinforcement and Post-Tensioning**. Place reinforcement as provided in Item 440, “Reinforcement for Concrete.” Do not weld reinforcing steel supports to other reinforcing steel except where shown on the plans.

Place post-tensioning ducts, anchorages, and other hardware in accordance with the approved prestressing details and Item 426, “Post-Tensioning.” Keep ducts free of obstructions until all post-tensioning operations are complete.

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

Do not place concrete when impending weather conditions would impair the quality of the finished work. Place concrete in early morning or at night or adjust the placement schedule for more favorable weather when conditions of wind, humidity, and temperature are such that concrete cannot be placed without the potential for weather-related distress.

Adequately illuminate the entire placement site as approved when mixing, placing, and finishing concrete in non-daylight hours.

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

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

4.7.1. **Placing Temperature**. Place concrete according to the following temperature limits for the classes of concrete defined in Section 421.4.1., “Classification of Concrete Mix Designs.”

- Place Class C, F, H, K, or SS concrete only when its temperature at time of placement is between 50°F and 95°F. Increase the minimum placement temperature to 60°F if slag cement is used in the concrete.
- Place Class S concrete, used in this Item only as indicated for culvert top slabs, only when its temperature is between 50°F and 85°F. Increase the minimum placement temperature to 60°F if slag cement is used in the concrete.
- Place Class A, B, and D concrete only when its temperature at the time of placement is greater than 50°F.
- Place mass concrete in accordance with Section 420.4.7.14., "Mass Placements," only when its temperature at the time of placement is between 50°F and 75°F.

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

4.7.3. **Workability of Concrete**. Place concrete with a slump as specified in Section 421.4.2.5., "Slump." Water may be added to the concrete before discharging any concrete from the truck to adjust for low slump provided that the maximum mix design water–cement ratio is not exceeded. Mix concrete in accordance with Section 421.4.6., "Mixing and Delivering Concrete," after introduction of any additional water or chemical admixtures. Do not add water or chemical admixtures after any concrete has been discharged.

4.7.4. **Transporting Concrete**. Transport concrete by buckets, chutes, buggies, belt conveyors, pumps, or other methods.

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

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

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

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

Ensure the subgrade or foundation is moist before placing concrete on grade. Lightly sprinkle the subgrade if dry.

4.7.6. **Expansion Joints**. Construct joints and devices to provide for expansion and contraction in accordance with plan details.

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

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

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

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

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

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

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

Thoroughly clean the hardened concrete surface of all loose material, laitance, dirt, and foreign matter, and saturate it with water. Remove all free water and moisten the surface before concrete or bonding grout is placed against it. Ensure the surface of the existing concrete is in a saturated surface-dry condition (SSD) just before placing subsequent concrete. Wet the existing concrete by ponding water on the surface for 24 hr. before placing subsequent concrete. Use high-pressure water blasting if ponding is not possible to achieve SSD conditions 15 to 30 min. before placing the concrete. An SSD condition is achieved when the surface remains damp when exposed to sunlight for 15 min.

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

Bonding agents are not required unless indicated otherwise. Coat the joint surface with bonding mortar, grout, epoxy, or other material if a bonding agent is required as indicated on the plans. Provide Type V epoxy per DMS-6100, "Epoxies and Adhesives," for bonding fresh concrete to hardened concrete. Place the bonding epoxy on a clean, dry surface, and place the fresh concrete while the epoxy is still tacky. Place bonding mortar or grout on a surface that is SSD, and place the concrete before the bonding mortar or grout dries. Place other bonding agents in accordance with the manufacturer's recommendations.

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

Ensure concrete free-falls no more than 5 ft. except in the case of drilled shafts, thin walls such as in culverts, or as allowed by other Items. Remove any hardened concrete splatter ahead of the plastic concrete.

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

Deposit concrete in the forms in layers of suitable depth but no more than 36 in. deep unless otherwise permitted.

Avoid cold joints in a monolithic placement. Sequence successive layers or adjacent portions of concrete so they can be vibrated into a homogeneous mass with the previously placed concrete before it sets. Allow no more than 1 hr. to elapse between adjacent or successive placements of concrete when re-vibration of the concrete is shown on the plans except as otherwise allowed by an approved placing procedure. This time limit may be extended by 1/2 hr. if the concrete contains at least the minimum recommended dosage of a Type B or D admixture.

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

Vibrate the concrete immediately after deposit. Systematically space points of vibration to ensure complete consolidation and thorough working of the concrete around the reinforcement, embedded fixtures, and into the corners and angles of the forms. Insert the vibrators vertically where possible. Vibrate the entire depth of each lift, allowing the vibrator to penetrate several inches into the preceding lift. Do not use the vibrator to move the concrete to other locations in the forms. Do not drag the vibrator through the concrete. Thoroughly consolidate concrete along construction joints by operating the vibrator along and close to but not against the joint surface. Continue the vibration until the concrete surrounding reinforcements and fixtures is completely

consolidated. Hand-spade or rod the concrete if necessary to ensure flushing of mortar to the surface of all forms.

4.7.10. **Installation of Dowels and Anchor Bolts**. Install dowels and anchor bolts by casting them in-place or by grouting with grout, epoxy, or epoxy mortar unless noted otherwise. Form or drill holes for grouting. Follow the manufacturer's recommended installation procedures for pre-packaged grout or epoxy anchor systems. Test anchors if required on the plans or by other Items.

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

Thoroughly clean holes of all loose material, oil, grease, or other bond-breaking substance, and blow them clean with filtered compressed air. Use a wire brush followed by oil-free compressed air to remove all loose material from the holes, repeating as necessary until no more material is removed. Ensure holes are in a surface-dry condition when epoxy type materials are used and in a surface-moist condition when cementitious grout is used. Develop and demonstrate for approval a procedure for cleaning and preparing the holes for installation of the dowels and anchor bolts. Completely fill the void between the hole and dowel or bolt with grouting material. Follow exactly the requirements for cleaning outlined in the product specifications for pre-packaged systems.

Provide hydraulic cement grout for cast-in-place or grouted systems in accordance with DMS-4675, "Cementitious Grouts and Mortars for Miscellaneous Applications." Provide a Type III epoxy per DMS-6100, "Epoxies and Adhesives," when neat epoxy is used for anchor bolts or dowels. Provide Type VIII epoxy per DMS-6100, "Epoxies and Adhesives," when an epoxy grout is used. Provide grout, epoxy, or epoxy mortar as the binding agent unless otherwise indicated on the plans.

Provide other anchor systems as required on the plans.

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

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

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

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

Use additional covering, insulated forms, or other means and, if necessary, supplement the covering with artificial heating. Avoid applying heat directly to concrete surfaces. Cure as specified in Section 420.4.10., "Curing Concrete," during this period until all requirements for curing have been satisfied.

Have all necessary heating and covering material ready for use before permission is granted to begin placement when impending weather conditions indicate the possible need for temperature protection.

4.7.12. **Placing Concrete in Hot Weather**. Keep the concrete at or below the maximum temperature at time of placement as specified in Section 420.4.7.1., "Placing Temperature." Sprinkle and shade aggregate stockpiles or use ice, liquid nitrogen systems, or other approved methods as necessary to control the concrete temperature.

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

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

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

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

4.7.14. **Mass Placements**. Develop and obtain approval for a heat control plan for monolithic placements designated on the plans as mass concrete to ensure the following during the heat dissipation period:

- the temperature differential between the central core of the placement and the exposed concrete surface does not exceed 35°F and
- the temperature at the central core of the placement does not exceed 160°F.

Use the ConcreteWorks© software available from the Department, or another approved method based on the guidelines in ACI 207, "Mass Concrete," to develop the heat control plan. The Department will make available technical assistance on the use of ConcreteWorks©. Develop the heat control plan using historical temperature ranges for the anticipated time of the mass placement. Re-create the plan if the work schedule shifts by more than one month.

The heat control plan may include a combination of the following elements:

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

Furnish and install 2 pairs of temperature recording devices, maturity meters, or other approved equivalent devices. Install devices to measure the surface temperature no more than 3 in. from the surface. Install devices to measure the core temperature a distance of half the least dimension from the nearest surface near the point of maximum predicted heat. Use these devices to simultaneously measure the temperature of the concrete at the core and the surface. Maintain temperature control methods for 4 days unless otherwise approved based on the submitted heat control plan. Do not use maturity meters to predict strength of mass concrete. Revise the heat control plan as necessary to maintain the temperature limitations shown above.

If the core temperature exceeds 160°F, the mass concrete element will be subject to review and acceptance by the Engineer using forensic analyses to determine its potential reduction in service life or performance. Proceed with subsequent construction on the affected element only when notified regarding acceptance.

Repair any resulting cracking if the temperature differential between the central core of the placement and the nearest concrete surface exceeds 35°F at no expense to the Department and revise the heat control plan as necessary to prevent further occurrences.

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

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

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

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

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

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

Accurately finish the footing slab at the proper time to provide a smooth uniform surface. Finish top slabs that carry direct traffic as specified in Item 422, “Concrete Superstructures.” Give top slabs of fill type culverts a float finish.

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

4.8.1. **Removal**. Remove portions of the existing structure to the lines and dimensions shown on the plans or as directed. Dispose of these materials as shown on the plans or as directed. Repair any portion of the remaining structure damaged as a result of the construction.

Do not use explosives to remove portions of the existing structure unless approved in writing. Do not use a demolition ball, other swinging weight, or impact equipment unless shown on the plans. Use pneumatic or hydraulic tools for final removal of concrete at the “break” line. Use removal equipment, as approved that will not damage the remaining concrete.

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

4.8.3. **Splicing Reinforcing Steel**. Splice new reinforcing bars to exposed bars in the existing structure using lap splices in accordance with Item 440, “Reinforcement for Concrete,” unless otherwise shown on the plans. The new reinforcing steel does not need to be tied to the existing steel where spacing or elevation does not match that of the existing steel provided the lap length is attained. Weld in accordance with Item 448, “Structural Field Welding,” when welded splices are permitted. Install any required dowels in accordance with Section 420.4.7.10., “Installation of Dowels and Anchor Bolts.”

4.8.4. **Concrete Preparation**. Roughen and clean concrete surfaces that are in contact with new construction before placing forms. Prepare these construction joint surfaces in accordance with Section 420.4.7.7., “Construction Joints.”

4.9. **Treatment and Finishing of Horizontal Surfaces**. Strike off to grade and finish all unformed upper surfaces. Do not use mortar topping for surfaces constructed under this Section.

Float the surface with a suitable float after the concrete has been struck off.

Slope the tops of caps and piers between bearing areas from the center slightly toward the edge, and slope the tops of abutment and transition bent caps from the backwall to the edge, as directed, so water drains from the surface. Give the concrete a smooth trowel finish. Construct bearing areas for steel units in accordance with Section 441.3.11.6., "Bearing and Anchorage Devices." Give the bearing area under the expansion ends of concrete slabs and slab and girder spans a steel-trowel finish to the exact grades required. Give bearing areas under elastomeric bearing pads or nonreinforced bearing seat buildups a textured, wood float finish. Do not allow the bearing area to vary from a level plane more than 1/16 in. in all directions.

Cast bearing seat buildups or pedestals for concrete units integrally with the cap or a construction joint. Provide a latex-based mortar, an epoxy mortar, or an approved proprietary bearing mortar for bearing seat buildups cast with a construction joint. Mix mortars in accordance with the manufacturer's recommendations. Construct pedestals of Class C concrete, reinforced as shown on the plans or as indicated in Figure 1 and Figure 2. The Engineer of Record will design pedestals higher than 12 in.

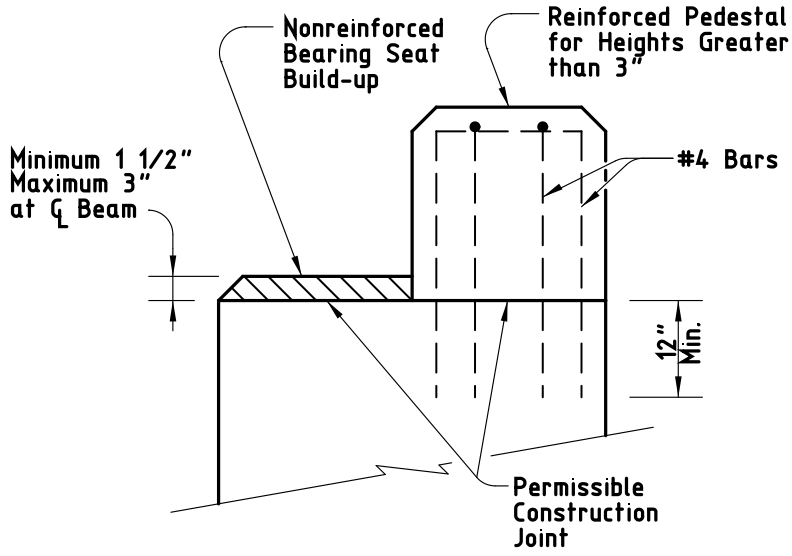


Figure 1
Section through Bearing Seat Buildups

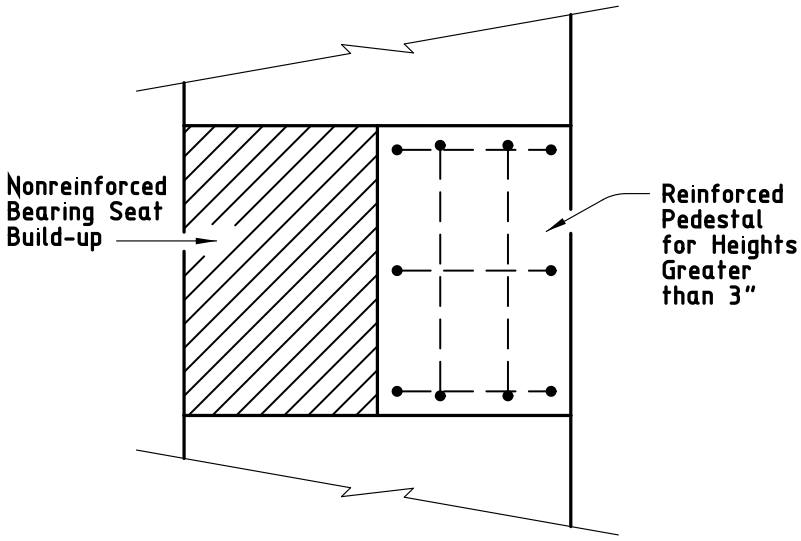


Figure 2
Plan View of Bearing Seat Buildups

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

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

Cure all concrete for 4 consecutive days except as allowed for the curing options listed below. Use form or membrane curing for vertical surfaces unless otherwise approved. Use only water curing for horizontal surfaces of HPC or mass concrete. Use water or membrane curing for horizontal or unformed surfaces for all other concrete.

Use one of the following curing options for vertical surfaces, unless indicated otherwise.

- Form cure for 48 hr. after placement.
- Form cure for 12 hr. after placement followed by membrane curing.
- For HPC Concrete, form cure for 48 hr. after placement followed by membrane curing.
- For mass concrete, form cure as required by the heat control plan followed by membrane curing if forms are removed before 4 days.

Apply membrane curing, if used, within 2 hr. of form removal.

Use only water curing in accordance with this Section for the top surface of any concrete unit upon which concrete is to be placed and bonded at a later interval (stub walls, caps with backwalls, risers, etc.).

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

4.10.1. **Form Curing**. When forms are left in intimate contact with the concrete, other curing methods are not required except for exposed surfaces and for cold weather protection. Use another approved curing method if forms are removed before the 4-day required curing period.

4.10.2. **Water Curing**. Keep all exposed surfaces of the concrete wet continuously for the required curing time. Use water curing in accordance with concrete mixing water in Section 421.2.5., "Water." Do not use seawater or water that stains or leaves an unsightly residue.

4.10.2.1. **Blankets**. Keep the concrete continuously wet by maintaining wet cotton or burlap mats in direct contact with the concrete for the required curing time. Weight the mats adequately to provide continuous contact with all concrete. Cover surfaces that cannot be cured by direct contact with mats, forming an enclosure well anchored to the forms or ground so outside air cannot enter the enclosure. Provide sufficient moisture inside the enclosure to keep all surfaces of the concrete wet.

4.10.2.2. **Water Spray**. Overlap sprays or sprinklers to keep all unformed surfaces continuously wet.

4.10.2.3. **Ponding**. Cover the surfaces with at least 2 in. of clean granular material, kept wet at all times, or at least 1 in. deep water. Use a dam to retain the water or saturated granular material.

4.10.3. **Membrane Curing**. Choose either Type 1-D or Type 2 membrane-curing compound unless otherwise shown on the plans. Use the same type of curing compound on an individual member.

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

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

4.11. **Removal of Forms and Falsework**. Remove forms for vertical surfaces after the concrete has aged a minimum of 12 hr. after initial set provided the removal can be done without damage to the concrete unless otherwise directed. Keep forms for mass placements in place for 4 days following concrete placement unless otherwise approved based on the outcome of the heat control plan outlined in Section 420.4.7.14., "Mass Placements."

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

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

Forms or parts of forms may be removed only if constructed to permit removal without disturbing forms or falsework required to be left in place for a longer period on other portions of the structure.

Remove all metal appliances used inside forms for alignment to a depth of at least 1/2 in. from the concrete surface. Make the appliances so metal may be removed without undue chipping or spalling of the concrete, and so it leaves a smooth opening in the concrete surface when removed. Do not burn off rods, bolts, or ties.

Remove all forms and falsework unless otherwise directed.

4.12. **Defective Work**. Repair defective work as soon as possible. Remove and replace at the expense of the Contractor any defect that cannot be repaired to the satisfaction of the Engineer.

4.13. **Ordinary Surface Finish**. Apply an ordinary surface finish to all concrete surfaces. Provide flat or textured surfaces as specified with uniform appearance. Address defects and surface irregularities not consistent with the intent of the expected finish by the following:

- Chip away all loose or broken material to sound concrete where porous, spalled, or honeycombed areas are visible after form removal.
- Repair spalls in accordance with the procedures outlined in the *Concrete Repair Manual* available on the Department's website.
- Clean and fill holes or spalls caused by the removal of form ties, etc., with latex grout, cement grout, or epoxy grout as approved. Fill only the holes. Do not blend the patch with the surrounding concrete. On surfaces to receive a rub finish in accordance with Item 427, "Surface Finishes for Concrete," chip out exposed parts of metals chairs to a depth of 1/2 in. and repair the surface.
- Remove all fins, rust staining, runs, drips, or mortar from surfaces that will be exposed. Smooth all form marks and chamfer edges by grinding or dry-rubbing.
- Ensure all repairs are dense, well-bonded, and properly cured. Finish exposed large repairs to blend with the surrounding concrete where a higher class of finish is not specified.

Apply an ordinary surface finish as the final finish to the following exposed surfaces unless noted otherwise:

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

Form marks and chamfer edges do not need to be smoothed for the inside of culvert barrels.

5. MEASUREMENT

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

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

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

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

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

5.2. **Plans Quantity**. Structure elements designated in Table 1 and measured by the cubic yard are plans quantity measurement items. The quantity to be paid for plans quantity items is the quantity shown in the proposal unless modified by Article 9.2., "Plans Quantity Measurement." Additional measurements or calculations will be made if adjustments of quantities are required.

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

Table 1
Plans Quantity Payment
(Cubic Yard Measurement Only)

Culverts and culvert wing walls	Abutments
Headwalls for pipe	Footings
Retaining walls	Pile bent caps
Inlets and manholes	Post-tensioned elements

Note—Other elements, including pier and bent concrete, may be paid for as "plans quantity" when shown on the plans.

5.3. **Measured in Place**. Items not paid for as "plans quantity" will be measured in place.

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for the class of concrete and element identified and by the special designation when appropriate. This price is full compensation for furnishing, hauling, and mixing concrete materials; furnishing, bending, fabricating, splicing, welding and placing the required reinforcement; clips, blocks, metal spacers, ties, wire, or other materials used for fastening reinforcement in place; furnishing, placing, and stressing post-tensioning system; placing, finishing, and curing concrete; mass placement controls; applying ordinary surface finish; furnishing and placing drains, metal flashing strips, and expansion-joint material; excavation, subgrade preparation; and forms and falsework, equipment, labor, tools, and incidentals.

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

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

In addition to the work described above, for extending structures the unit prices bid for the various classifications of concrete shown are full compensation for removing and disposing of, if necessary, the designated portion of the existing structure; removing, stockpiling if necessary, and replacing headwall units for reuse; cleaning, bending, and cutting of exposed reinforcing steel; splicing of new reinforcing steel to existing reinforcing steel; installation of dowels; and cleaning and preparing existing concrete surfaces.

Item 421
Hydraulic Cement Concrete

1. DESCRIPTION

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

2. MATERIALS

Use materials from prequalified sources listed on the Department website. Provide coarse and fine aggregates from sources listed in the Department's *Concrete Rated Source Quality Catalog* (CRSQC). Use materials from non-listed sources only when tested and approved by the Engineer before use. Allow 30 calendar days for the Engineer to sample, test, and report results for non-listed sources. Do not combine approved material with unapproved material.

2.1. **Cement**. Furnish cement conforming to DMS-4600, "Hydraulic Cement."

2.2. **Supplementary Cementing Materials (SCM)**.

- **Fly Ash**. Furnish fly ash, ultra-fine fly ash (UFFA), and modified Class F fly ash (MFFA) conforming to DMS-4610, "Fly Ash."
- **Slag Cement**. Furnish Slag Cement conforming to DMS-4620, "Slag Cement."
- **Silica Fume**. Furnish silica fume conforming to DMS-4630, "Silica Fume."
- **Metakaolin**. Furnish metakaolin conforming to DMS-4635, "Metakaolin."

2.3. **Cementitious Material**. Cementitious materials are the cement and supplementary cementing materials used in concrete.

2.4. **Chemical Admixtures**. Furnish admixtures conforming to DMS-4640, "Chemical Admixtures for Concrete."

2.5. **Water**. Furnish mixing and curing water that is free from oils, acids, organic matter, or other deleterious substances. Water from municipal supplies approved by the Texas Department of Health will not require testing. Provide test reports showing compliance with Table 1 before use when using water from other sources.

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

Table 1
Chemical Limits for Mix Water

Contaminant	Test Method	Maximum Concentration (ppm or mg\L)
Chloride (Cl)	ASTM C114	
Prestressed concrete		500
Bridge decks & superstructure		500
All other concrete		1,000
Sulfate (SO4)	ASTM C114	2,000
Alkalies (Na2O + 0.658K2O)	ASTM C114	600
Total solids	ASTM C1603	50,000

Table 2
Acceptance Criteria for Questionable Water Supplies

Property	Test Method	Limits
Compressive strength, min % control at 7 days	ASTM C31, ASTM C39[1,2]	90
Time of set, deviation from control, h:min.	ASTM C403	From 1:00 early to 1:30 later

1. Base comparisons on fixed proportions and the same volume of test water compared to the control mix using 100% potable water or distilled water.
2. Base comparisons on sets consisting of at least 2 standard specimens made from a composite sample.

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

2.6. **Aggregate**.

2.6.1. **Coarse Aggregate**. Provide coarse aggregate consisting of durable particles of gravel, crushed blast furnace slag, recycled crushed hydraulic cement concrete, crushed stone, or combinations which are free from frozen material and from injurious amounts of salt, alkali, vegetable matter, or other objectionable material, either free or as an adherent coating. Provide coarse aggregate of uniform quality throughout.

Provide coarse aggregate with the requirements listed in Table 3 unless otherwise shown on the plans.

Table 3
Coarse Aggregate Requirements

Description	Test Method	Limit
Weight of Clay Lumps, % Max	Tex-413-A	0.25
Weight of Shale, % Max		1.0
Weight of Laminate and Friable Particle, % Max		5.0
L.A. Abrasion Wear, % Max	Tex-410-A	40
5-Cycle Magnesium Sulfate Soundness,[1,2] non-air-entrained concrete, % Max	Tex-411-A	25
5-Cycle Magnesium Sulfate Soundness,[1,3] air-entrained concrete, % Max		18
Loss by Decantation, % Max	Tex-406-A	1.5

1. Recycled crushed hydraulic cement concrete is not subject to 5-cycle magnesium sulfate soundness requirements.
2. Allowed when air-entrained concrete is used at the Contractor's option.
3. Only when air-entrained concrete is required by the plans.

Increase the loss by decantation limit to 3.0% for all classes of concrete and 5.0% for Class A, B, and P if the material finer than the No. 200 sieve is determined to be at least 85% calcium carbonate in accordance with Tex-406-A, Part III, in the case of coarse aggregates made primarily from crushing stone unless otherwise shown on the plans. Provide test results upon request.

Provide coarse aggregate or combination of aggregates conforming to the gradation requirements shown in Table 4 when tested in accordance with Tex-401-A unless otherwise specified.

Table 4
Coarse Aggregate Gradation Chart

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

1. Corresponding ASTM C33 gradation shown in parentheses.

2.6.2. **Fine Aggregate**. Provide fine aggregate consisting of clean, hard, durable particles of natural, manufactured sand, recycled crushed hydraulic cement concrete, slag, lightweight aggregate, or a combination thereof. Provide fine aggregate free from frozen material and from injurious amounts of salt, alkali, vegetable matter, or other objectionable material.

Provide fine aggregates with the requirements in Table 5 unless otherwise shown on the plans.

Table 5
Fine Aggregate Requirements

Description	Test Method	Limit
Weight of Clay Lumps, % Max	Tex-413-A	0.50
Organic Impurities[1]	Tex-408-A	Color not darker than standard
Sand Equivalent	Tex-203-F	80
Fineness Modulus	Tex-402-A	2.3 to 3.1

1. Only when air-entrained concrete is specified.

Provide fine aggregate or combinations of aggregates conforming to the gradation requirements shown in Table 6 when tested in accordance with Tex-401-A unless otherwise specified.

Table 6
Fine Aggregate Gradation Chart (Grade 1)

Sieve Size	Percent Passing
3/8"	100
#4	95–100
#8	80–100
#16	50–85
#30	25–65
#50	10–35[1]
#100	0–10
#200	0–3[2]

1. 6–35 when sand equivalent value is greater than 85.
2. 0–6 for manufactured sand.

2.6.3. **Intermediate Aggregate**. Provide intermediate aggregate consisting of clean, hard, durable particles of natural, manufactured sand, slag, recycled crushed hydraulic cement concrete, lightweight aggregate, or a combination thereof when optimized aggregate gradation (OAG) concrete is specified or when used at the Contractor's option. Provide intermediate aggregate free from frozen material and injurious amounts of salt, alkali, vegetable matter, or other objectionable material.

Provide intermediate aggregate with the requirements in Table 7.

Table 7
Intermediate Aggregate Requirements

Description	Test Method	Limit
Weight of Clay Lumps, % Max	Tex-413-A	0.50
L.A. Abrasion Wear,[1] % Max	Tex-410-A	40
5-Cycle Magnesium Sulfate Soundness,[1,2,3] non-air-entrained concrete, % Max	Tex-411-A	25
5-Cycle Magnesium Sulfate Soundness,[1,2,4] air-entrained concrete, % Max		18
Organic Impurities[5]	Tex-408-A	Color not darker than standard
Loss by Decantation,[1] % Max	Tex-406-A	1.5

1. Only applies to the portion retained on the No. 4 sieve, if more than 30% of the intermediate aggregate is retained on the No. 4 sieve.
2. Recycled crushed hydraulic cement concrete is not subject to 5-cycle magnesium sulfate soundness requirements.
3. Allowed when air-entrained concrete is used at the Contractor's option.
4. Only when air-entrained concrete is required by the plans.
5. Only applies to the portion passing the 3/8 in. sieve, if more than 30% of the intermediate aggregate is passing the 3/8 in. sieve.

For the portion retained on the No. 4 sieve, if more than 30% of the intermediate aggregate is retained on the No. 4 sieve, and in the case of aggregates made primarily from crushing stone, unless otherwise shown on the plans, the loss by decantation may be increased to 3.0% for all classes of concrete and 5.0% for Class A, B, and P if the material finer than the No. 200 sieve is determined to be at least 85% calcium carbonate in accordance with Tex-406-A, Part III. Provide test results upon request.

2.7. **Mortar and Grout**. Furnish pre-packaged grouts conforming to DMS-4675, "Cementitious Grouts and Mortars for Miscellaneous Applications," when specified for applications other than post-tension grouting.

Section 421.4.2.6., "Mix Design Options," does not apply for mortar and grout.

2.8. **Storage of Materials**.

2.8.1. **Cement and Supplementary Cementing Materials**. Store all cement and supplementary cementing materials in weatherproof enclosures that will protect them from dampness or absorption of moisture.

When permitted, small quantities of packaged cementitious material may be stored in the open, on a raised platform, and under waterproof covering for up to 48 hr.

2.8.2. **Aggregates**. Handle and store concrete aggregates in a manner that prevents contamination with foreign materials. Clear and level the sites for the stockpiles of all vegetation if the aggregates are stored on the ground and do not use the bottom 6-in. layer of aggregate without cleaning the aggregate before use.

Maintain separate stockpiles and prevent intermixing when conditions require the use of 2 or more grades of coarse aggregates. Separate the stockpiles using physical barriers where space is limited. Store aggregates from different sources in different stockpiles unless the Engineer authorizes pre-blending of the aggregates. Minimize segregation in stockpiles. Remix and test stockpiles when segregation is apparent.

Sprinkle stockpiles to control moisture and temperature as necessary. Maintain reasonably uniform moisture content in aggregate stockpiles.

2.8.3. **Chemical Admixtures**. Store admixtures in accordance with manufacturer's recommendations and prevent admixtures from freezing.

3. EQUIPMENT

3.1. **Concrete Plants and Mixing Equipment**. Except for volumetric stationary plant or truck (auger) mixers, each plant and truck mixer must be currently certified by the National Ready Mixed Concrete Association (NRMCA) or have an inspection report signed and sealed by a licensed professional engineer showing concrete measuring, mixing, and delivery equipment meets all requirements of ASTM C94. A new

certification or signed and sealed report is required every time a plant is moved. Plants with a licensed professional engineer's inspection require re-inspection every 2 yr. Provide a copy of the certification or the signed and sealed inspection report to the Engineer. Remove equipment or facilities from service until corrected when they fail to meet specification requirements.

When allowed on the plans or by the Engineer, for concrete classes not identified as structural concrete in Table 8 or for Class C concrete not used for bridge-class structures, the Engineer may inspect and approve all plants and trucks instead of the NRMCA or non-Department engineer-sealed certifications. The criteria and frequency of Engineer approval of plants and trucks is the same used for NRMCA certification.

Inspect and furnish inspection reports on the condition of blades and fins and their percent wear from the original manufacturer's design for truck mixers and agitators annually. Repair mixing equipment exhibiting 10% or more wear before use. If an inspection within 12 mo. is not practical, a 2-mo. grace period (for a maximum of 14 mo. between inspections) is permitted.

3.1.1. **Scales**. Check all scales before beginning of operations, after each move, or whenever their accuracy or adequacy is questioned, and at least once every 6 mo. Immediately correct deficiencies, and recalibrate. Provide a record of calibration showing scales in compliance with ASTM C94 requirements. Check batching accuracy of volumetric water batching devices at least every 90 days. Check batching accuracy of chemical admixture dispensing devices at least every 6 mo. Perform daily checks as necessary to ensure measuring accuracy.

3.1.2. **Volumetric Mixers**. Provide volumetric mixers with rating plates defining the capacity and the performance of the mixer in accordance with the Volumetric Mixer Manufacturers Bureau or equivalent. Provide volumetric mixers that comply with ASTM C685. Provide test data showing mixers meet the uniformity test requirements of Tex-472-A.

Unless allowed on the plans or by the Engineer, volumetric truck (auger) mixers may not supply classes of concrete identified as structural concrete in Table 8.

3.1.3. **Agitators and Truck and Stationary Mixers**. Provide stationary and truck mixers capable of combining the ingredients of the concrete into a thoroughly mixed and uniform mass and capable of discharging the concrete so at least 5 of the 6 requirements of Tex-472-A are met.

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

Perform the mixer or agitator uniformity test at the full rated capacity of the equipment. Remove all equipment that fails the uniformity test from service.

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

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

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

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

Maintain hauling equipment clean and free of built-up concrete.

3.3. **Testing Equipment**. Furnish and maintain the following in accordance with the pertinent test procedure unless otherwise shown on the plans or specified:

- sieves necessary to perform aggregate gradation analysis when optimized aggregate gradation is specified,
- equipment necessary to perform Tex-415-A and Tex-422-A,
- equipment necessary to perform Tex-409-A or Tex-425-A,
- test molds,
- curing facilities,
- maturity meters if used, and
- wheelbarrow or other container acceptable for the sampling of the concrete.

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

4. CONSTRUCTION

4.1. **Classification of Concrete Mix Designs**. Provide classes of concrete meeting the requirements shown in Table 8.

A higher-strength class of concrete with equal or lower water-to-cementitious material (w/cm) ratio may be substituted for the specified class of concrete when approved.

4.2. **Mix Design Proportioning**. Furnish mix designs using ACI 211, Tex-470-A, or other approved procedures for the classes of concrete listed in Table 8 unless a design method is indicated on the plans. Perform mix design proportioning by absolute volume method unless otherwise approved. Perform cement replacement using equivalent weight method unless otherwise approved.

Do not exceed the maximum w/cm ratio listed in Table 8 when designing the mixture.

4.2.1. **Cementitious Materials**. Do not exceed 700 lb. of cementitious material per cubic yard of concrete unless otherwise specified or approved.

- Use cement of the same type and from the same source for monolithic placements.
- Do not use supplementary cementing materials when white hydraulic cement is specified.

Table 8
Concrete Classes

Class of Concrete	Design Strength,[1] Min f'_c (psi)	Max w/cm Ratio	Coarse Aggregate Grades[2,3,4]	Cement Types	Mix Design Options	Exceptions to Mix Design Options	General Usage[5]
A	3,000	0.60	1–4, 8	I, II, I/II, IL, IP, IS, IT, V	1, 2, 4, & 7	When the cementitious material content does not exceed 520 lb./cu. yd., Class C fly ash may be used instead of Class F fly ash.	Curb, gutter, curb & gutter, conc. retards, sidewalks, driveways, back-up walls, anchors, non-reinforced drilled shafts
B	2,000	0.60	2–7				Riprap, traffic signal controller foundations, small roadside signs, and anchors
C[6]	3,600	0.45	1–6	I, II, I/II, IP, IS, IT,[7] V	1–8		Drilled shafts, bridge substructure, bridge railing, culverts except top slab of direct traffic culverts, headwalls, wing walls, inlets, manholes, concrete traffic barrier (cast-in-place)
E	3,000	0.50	2–5	I, II, I/II, IL, IP, IS, IT,[7] V	1–8	When the cementitious material content does not exceed 520 lb./cu. yd., Class C fly ash may be used instead of Class F fly ash.	Seal concrete

Table 8 (continued)

Concrete Classes

Class of Concrete	Design Strength,[1] Min f'_c (psi)	Max w/cm Ratio	Coarse Aggregate Grades[2,3,4]	Cement Types	Mix Design Options	Exceptions to Mix Design Options	General Usage[5]
F[6]	Note 8	0.45	2–5	I, II, I/II, IP, IS, IT,[7]V			Railroad structures; occasionally for bridge piers, columns, or bents
H[6]	Note 8	0.45	3–6	I, II, I/II, III, IP, IS, IT,[7] V	1–5	Do not use Type III cement in mass placement concrete. Up to 20% of blended cement may be replaced with listed SCMs when Option 4 is used for precast concrete.	Precast concrete, post-tension members
S[6]	4,000	0.45	2–5	I, II, I/II, IP, IS, IT,[7]V	1–8		Bridge slabs, top slabs of direct traffic culverts, approach slabs
P	See Item 360, "Concrete Pavement."	0.50	2–3	I, II, I/II, IL, IP, IS, IT, V	1–8	When the cementitious material content does not exceed 520 lb./cu. yd., Class C fly ash may be used instead of Class F fly ash.	Concrete pavement
CO[6]	4,600	0.40	6	I, II, I/II, IP, IS, IT,[7] V	1–8		Bridge deck concrete overlay
LMC[6]	4,000	0.40	6–8				Latex-modified concrete overlay
SS[6]	3,600	0.45	4–6			Use a minimum cementitious material content of 658 lb./cu. yd. of concrete.	Slurry displacement shafts, underwater drilled shafts
K[6]	Note 8	0.40	Note 8	I, II, I/II, III IP, IS, IT,[7] V			Note 8
HES	Note 8	0.45	Note 8	I, IL, II, I/II, III		Mix design options do not apply. 700 lb. of cementitious material per cubic yard limit does not apply.	Concrete pavement, concrete pavement repair
"X" (HPC) [6,9,10]	Note 11	0.45	Note 11	I, II, I/II, III IP, IS, IT,[7] V	1–5, & 8	Maximum fly ash replacement for Options 1 and 3 may be increased to 45%. Up to 20% of a blended cement may be replaced with listed SCMs for Option 4. Do not use Option 8 for precast concrete.	
"X" (SRC) [6,9,10]	Note 11	0.45	Note 11	I/II, II, IP, IS, IT,[7] V	1–4 , & 7	Do not use Class C Fly Ash Type III-MS may be used where allowed. Type I and Type III cements may be used with Options 1–3, with a maximum w/cm of 0.40. Up to 20% of blended cement may be replaced with listed SCMs when Option 4 is used for precast concrete. Do not use Option 7 for precast concrete.	

Class of Concrete	Design Strength,[1] Min f'_c (psi)	Max w/cm Ratio	Coarse Aggregate Grades[2,3,4]	Cement Types	Mix Design Options	Exceptions to Mix Design Options	General Usage[5]

3. Design strength must be attained within 56 days.
4. Do not use Grade 1 coarse aggregate except in massive foundations with 4 in. minimum clear spacing between reinforcing steel bars, unless otherwise permitted. Do not use Grade 1 aggregate in drilled shafts.
5. Use Grade 8 aggregate in extruded curbs unless otherwise approved.
6. Other grades of coarse aggregate maybe used in non-structural concrete classes when allowed by the Engineer.
7. For information only.
8. Structural concrete classes.
9. Do not use Type IT cements containing > 5% limestone.
10. As shown on the plans or specified.
11. "X" denotes class of concrete shown on the plans or specified.
12. (HPC): High Performance Concrete, (SRC): Sulfate Resistant Concrete.
13. Same as class of concrete shown on the plans.

4.2.2. **Aggregates**. Recycled crushed hydraulic cement concrete may be used as a coarse or fine aggregate in Class A, B, E, and P concrete. Limit recycled crushed concrete fine aggregate to a maximum of 20% of the fine aggregate.

Use light-colored aggregates when white hydraulic cement is specified.

Use fine aggregate with an acid insoluble residue of at least 60% by weight when tested in accordance with Tex-612-J in all concrete subject to direct traffic.

Use the following equation to determine if the aggregate combination meets the acid insoluble residue requirement when blending fine aggregate or using an intermediate aggregate:

$$\frac{(A_1 \times P_1)+(A_2 \times P_2)+(A_{ia} \times P_{ia})}{100} \geq 60\%$$

where:
A_1 = acid insoluble (%) of fine aggregate 1
A_2 = acid insoluble (%) of fine aggregate 2
A_{ia} = acid insoluble (%) of intermediate aggregate passing the 3/8 in. sieve
P_1 = percent by weight of fine aggregate 1 of the fine aggregate blend
P_2 = percent by weight of fine aggregate 2 of the fine aggregate blend
P_{ia} = percent by weight of intermediate aggregate passing the 3/8 in. sieve

Alternatively to the above equation, blend fine aggregate with a micro-deval loss of less than 12%, when tested in accordance with Tex-461-A, with at least 40% of a fine aggregate with an acid insoluble residue of at least 60%.

4.2.3. **Chemical Admixtures**. Do not use Type C, Type E, Type F, or Type G admixtures in Class S bridge deck concrete. Do not use chemical admixtures containing calcium chloride in any concrete.

Use a 30% calcium nitrite solution when a corrosion-inhibiting admixture is required. The corrosion-inhibiting admixture must be set neutral unless otherwise approved. Dose the admixture at the rate of gallons of admixture per cubic yard of concrete shown on the plans.

4.2.4. **Air Entrainment**. Use an approved air-entraining admixture when air-entrained concrete is specified, or when an air-entraining admixture is used at the Contractor's option, and do not exceed the manufacturer's recommended dosage. Ensure the minimum entrained air content is at least 3.0% for all classes of concrete except Class P when air-entrained concrete is specified, during trial batch, or when providing previous field data.

4.2.5. **Slump**. Provide concrete with a slump in accordance with Table 9 unless otherwise specified. When approved, the slump of a given concrete mix may be increased above the values shown in Table 9 using chemical admixtures, provided the admixture-treated concrete has the same or lower water-to-cementitious material ratio and does not exhibit segregation or excessive bleeding. Request approval to exceed the slump limits in Table 9 sufficiently in advance for proper evaluation by the Engineer.

Perform job-control testing of slump in accordance with Section 421.4.8.3.1., "Job-Control Testing."

Table 9
Placement Slump Requirements

General Usage[1]	Placement Slump Range,[2] in.
Walls (over 9 in. thick), caps, columns, piers, approach slabs, concrete overlays	3 to 5
Bridge slabs, top slabs of direct traffic culverts, latex-modified concrete for bridge deck overlays	3 to 5-1/2
Inlets, manholes, walls (less than 9 in. thick), bridge railing, culverts, concrete traffic barrier, concrete pavement (formed), seal concrete	4 to 5-1/2
Precast concrete	4 to 9
Underwater concrete placements	6 to 8-1/2
Drilled shafts, slurry displaced and underwater drilled shafts	See Item 416, "Drilled Shaft Foundations."
Curb, gutter, curb and gutter, concrete retards, sidewalk, driveways, anchors, riprap, small roadside sign foundations, concrete pavement repair, concrete repair	As approved

1. For information only.
2. For fiber reinforced concrete, perform slump before addition of fibers.

4.2.6. **Mix Design Options**.

4.2.6.1. **Option 1**. Replace 20% to 35% of the cement with Class F fly ash.

4.2.6.2. **Option 2**. Replace 35% to 50% of the cement with slag cement or MFFA.

4.2.6.3. **Option 3**. Replace 35% to 50% of the cement with a combination of Class F fly ash, slag cement, MFFA, UFFA, metakaolin, or silica fume; however, no more than 35% may be fly ash, and no more than 10% may be silica fume.

4.2.6.4. **Option 4**. Use Type IP, Type IS, or Type IT cement as allowed in Table 5 for each class of concrete. Up to 10% of a Type IP, Type IS, or Type IT cement may be replaced with Class F fly ash, slag cement, or silica fume. Use no more than 10% silica fume in the final cementitious material mixture if the Type IT cement contains silica fume, and silica fume is used to replace the cement.

4.2.6.5. **Option 5**. Replace 35% to 50% of the cement with a combination of Class C fly ash and at least 6% of silica fume, UFFA, or metakaolin. However, no more than 35% may be Class C fly ash, and no more than 10% may be silica fume.

4.2.6.6. **Option 6**. Use a lithium nitrate admixture at a minimum dosage determined by testing conducted in accordance with Tex-471-A. Before use of the mix, provide an annual certified test report signed and sealed by a licensed professional engineer, from a laboratory on the Department's MPL, certified by the Construction Division as being capable of testing according to Tex-471-A.

4.2.6.7. **Option 7**. Ensure the total alkali contribution from the cement in the concrete does not exceed 3.5 lb. per cubic yard of concrete when using hydraulic cement not containing SCMs calculated as follows:

$$\text{lb. alkali per cu. yd.} = \frac{(\text{lb. cement per cu. yd.}) \times (\%\ Na_2O \text{ equivalent in cement})}{100}$$

In the above calculation, use the maximum cement alkali content reported on the cement mill certificate.

4.2.6.8. **Option 8**. Perform annual testing as required for any deviations from Options 1–5 or use mix design options listed in Table 10. Laboratories performing ASTM C1260, ASTM C1567, and ASTM C1293 testing must be listed on the Department's MPL. Before use of the mix, provide a certified test report signed and sealed by a licensed professional engineer demonstrating the proposed mixture conforms to the requirements of Table 10.

Provide a certified test report signed and sealed by a licensed professional engineer, when HPC is required, and less than 20% of the cement is replaced with SCMs, demonstrating ASTM C1202 test results indicate the permeability of the concrete is less than 1,500 coulombs tested immediately after either of the following curing schedules:

- Moisture cure specimens 56 days at 73°F.
- Moisture cure specimens 7 days at 73°F followed by 21 days at 100°F.

Table 10
Option 8 Testing and Mix Design Requirements

Scenario	ASTM C1260 Result		Testing Requirements for Mix Design Materials or Prescriptive Mix Design Options[1]
	Mix Design Fine Aggregate	Mix Design Coarse Aggregate	
A	> 0.10%	> 0.10%	Determine the dosage of SCMs needed to limit the 14-day expansion of each aggregate[2] to 0.08% when tested individually in accordance with ASTM C1567; or Use a minimum of 40% Class C fly ash with a maximum CaO[3] content of 25%.
B	≤ 0.10%	≤ 0.10%	Use a minimum of 40% Class C fly ash with a maximum CaO[3] content of 25%; or Use any ternary combination which replaces 35% to 50% of cement.
	≤ 0.10%	ASTM C1293 1 yr. Expansion ≤ 0.04%	Use a minimum of 20% of any Class C fly ash; or Use any ternary combination which replaces 35% to 50% of cement.
C	≤ 0.10%	> 0.10%	Determine the dosage of SCMs needed to limit the 14-day expansion of coarse and intermediate[2] aggregate to 0.08% when tested individually in accordance with ASTM C1567; or Use a minimum of 40% Class C fly ash with a maximum CaO[3] content of 25%.
D	> 0.10%	≤ 0.10%	Use a minimum of 40% Class C fly ash with a maximum CaO[3] content of 25%; or Use any ternary combination which replaces 35% to 50% of cement.
	> 0.10%	ASTM C1293 1 yr. Expansion ≤ 0.04%	Determine the dosage of SCMs needed to limit the 14-day expansion of fine aggregate to 0.08% when tested in accordance with ASTM C1567.

1. Do not use Class C fly ash if the ASTM C1260 value of the fine, intermediate, or coarse aggregate is 0.30% or greater, unless the fly ash is used as part of a ternary system.
2. Intermediate size aggregates will fall under the requirements of mix design coarse aggregate.
3. Average the CaO content from the previous ten values as listed on the mill certificate.

4.2.7. **Optimized Aggregate Gradation (OAG) Concrete**. The gradation requirements in Table 3 and Table 4 do not apply when OAG concrete is specified or used by the Contractor unless otherwise shown on the plans. Use Tex-470-A to establish the optimized aggregate gradation. Use at least 420 lb. per cubic yard of cementitious material when OAG concrete is used unless otherwise approved. Use a coarse aggregate with a maximum nominal size of 1-1/2 in. for Class P concrete. Use a coarse aggregate for all other classes of concrete with a maximum nominal size not larger than:

- 1/5 the narrowest dimension between sides of forms, or
- 1/3 the depth of slabs, or
- 3/4 the minimum clear spacing between individual reinforcing bars or wires, bundles of bars, individual tendons, bundled tendons, or ducts.

Make necessary adjustments to individual aggregate stockpile proportions during OAG concrete production when the gradation deviates from the optimized gradation requirements.

4.2.8. **Self-Consolidating Concrete (SCC)**. Provide SCC meeting the following requirements shown in Table 11 when approved for use in precast concrete. Use concrete with a slump flow that can be placed without vibration and will not segregate or excessively bleed.

Request approval to exceed the slump flow limits sufficiently in advance for proper evaluation by the Engineer.

Table 11
Mix Design Requirements for SCC

Tests	Test Method	Acceptable Limits
Slump Flow for Precast Concrete	ASTM C1611	22 to 27[1]
T_{50}, sec	ASTM C1611	2 to 7
VSI Rating	ASTM C1611	0 or 1
Passing Ability, in.	ASTM C1621	≤ 2
Segregation Column, %	ASTM C1610	≤ 10
Bleeding, %	ASTM C232	≤ 2.5

1. These slump flow limits are generally acceptable for most applications. However, slump flow limits may be adjusted during mix design approval process and when approved by the Engineer.

4.3. **Concrete Trial Batches**. Perform preliminary and final trial batches when required by the plans, or when previous satisfactory field data is not available. Submit previous satisfactory field data to the Engineer showing the proposed mix design conforms to specification requirements when trial batches are not required and before concrete is placed.

Perform preliminary and final trial batches for all self-consolidating concrete mix designs.

4.3.1. **Preliminary Trial Batches**. Perform all necessary preliminary trial batch testing when required, and provide documentation including mix design, material proportions, and test results substantiating the mix design conforms to specification requirements.

4.3.2. **Final Trial batches**. Make all final trial batches using the proposed ingredients in a mixer that is representative of the mixers to be used on the job when required. Make the batch size at least 50% of the mixer's rated capacity. Perform fresh concrete tests for air content and slump, and make, cure, and test strength specimens for compliance with specification requirements. Test at least one set of design strength specimens, consisting of 2 specimens per set, at 7-day, 28-day, and at least one additional age unless otherwise directed. Before placing, provide the Engineer the option of witnessing final trial batches, including the testing of the concrete. If not provided this option, the Engineer may require additional trial batches, including testing, before the concrete is placed.

Conduct all testing listed in Table 11 when performing trial batches for self-consolidating concrete. Make an additional mixture with 3% more water than the preliminary trial batch. Make necessary adjustments to the mix design if this additional mixture does not meet requirements of Table 11. Cast and evaluate mock-ups for precast concrete that are representative of the actual product as directed. Provide the Engineer the option of witnessing final trial batches, including the testing of the concrete and the casting of the mock-ups before placement. If not provided this option, the Engineer may require additional trial batches, including testing and mock-ups, before the concrete is placed.

Establish 7-day compressive strength target values using the following formula for each Class A, B, and E concrete mix designs to be used:

$$\text{Target value} = \text{Minimum design strength} \times \frac{\text{7 - day avg. trial batch strength}}{\text{28 - day avg. trial batch strength}}$$

Submit previous satisfactory field data, data from a new trial batch, or other evidence showing the change will not adversely affect the relevant properties of the concrete when changes are made to the type, brand, or source of aggregates, cement, SCM, water, or chemical admixtures. Submit the data for approval before making changes to the mix design. A change in vendor does not necessarily constitute a change in materials

or source. The Engineer may waive new trial batches when there is a prior record of satisfactory performance with the ingredients. During concrete production, dosage changes of chemical admixtures used in the trial batches will not require a re-evaluation of the mix design.

The Contractor has the option of performing trial batches in conjunction with concrete placements except for SCC mixtures, when new trial batches are required during the course of the project. If the concrete fails to meet any requirement, the Engineer will determine acceptability and payment adjustments.

Establish the strength–maturity relationship in accordance with Tex-426-A when the maturity method is specified or permitted. When using the maturity method, any changes in any of the ingredients, including changes in proportions, will require the development of a new strength–maturity relationship for the mix.

4.3.3. **Mix Design of Record**. Once a trial batch or previously satisfactory field data substantiates the mix design, the proportions and mixing methods used become the mix design of record. Do not exceed mix design water-to-cementitious material ratio.

4.4. **Production Testing**.

4.4.1. **Aggregate Moisture Testing**. Determine moisture content per Tex-409-A or Tex-425-A for coarse, intermediate, and fine aggregates at least twice a week, when there is an apparent change, or for new shipments of aggregate. When aggregate hoppers or storage bins are equipped with properly maintained electronic moisture probes for continuous moisture determination, moisture tests per Tex-409-A or Tex-425-A are not required. Electronic moisture probes, however, must be verified at least every 90 days against Tex-409-A and be accurate to within 1.0% of the actual moisture content.

When producing SCC, and when aggregate hoppers or storage bins are not equipped with electric moisture probes, determine the moisture content of the aggregates before producing the first concrete batch each day. Thereafter, determine the moisture content every 4 hr. or when there is an apparent change while SCC is being produced.

4.4.2. **Aggregate Gradation Testing**. Perform a sieve analysis in accordance with Tex-401-A on each stockpile used in the blend at least one day before producing OAG concrete when producing optimized aggregate gradation concrete. Perform sieve analysis on each stockpile after every 10,000 cubic yards of OAG concrete produced. Provide sieve analysis data to the Engineer.

4.5. **Measurement of Materials**.

4.5.1. **Non-Volumetric Mixers**. Measure aggregates by weight. Correct batch weight measurements for aggregate moisture content. Measure mixing water, consisting of water added to the batch, ice added to the batch, water occurring as surface moisture on the aggregates, and water introduced in the form of admixtures, by volume or weight. Measure ice by weight. Measure cement and supplementary cementing materials in a hopper and on a separate scale from those used for other materials. Measure the cement first when measuring the cumulative weight. Measure concrete chemical admixtures by weight or volume. Measure batch materials within the tolerances of Table 12.

Table 12
Mix Design Batching Tolerances—Non-Volumetric Mixers

Material	Tolerance (%)
Cement, wt.	–1 to +3
SCM, wt.	–1 to +3
Cement + SCM (cumulative weighing), wt.	–1 to +3
Water, wt. or volume	±3[1]
Fine aggregate, wt.	±2
Coarse aggregate, wt.	±2
Fine + coarse aggregate (cumulative weighing), wt.	±1
Chemical admixtures, wt. or volume	±3

1. Allowable deviation from target weight not including water withheld or moisture in the aggregate. The Engineer will verify the water-to-cementitious material ratio is within specified limits.

Ensure the quantity measured, when measuring cementitious materials at less than 30% of scale capacity, is accurate to not less than the required amount and not more than 4% in excess. Ensure the cumulative quantity, when measuring aggregates in a cumulative weigh batcher at less than 30% of the scale capacity, is measured accurate to ±0.3% of scale capacity or ±3% of the required cumulative weight, whichever is less.

Measure cement in number of bags under special circumstances when approved. Use the weights listed on the packaging. Weighing bags of cement is not required. Ensure fractional bags are not used except for small hand-mixed batches of approximately 5 cu. ft. or less and when an approved method of volumetric or weight measurement is used.

4.5.2. **Volumetric Mixers**. Provide an accurate method of measuring all ingredients by volume, and calibrate equipment to assure correct measurement of materials within the specified tolerances. Base tolerances on volume–weight relationship established by calibration, and measure the various ingredients within the tolerances of Table 13. Correct batch measurements for aggregate moisture content.

Table 13
Mix Design Batching Tolerances—Volumetric Mixers

Material	Tolerance
Cement, wt. %	0 to +4
SCM, wt. %	0 to +4
Fine aggregate, wt. %	±2
Coarse aggregate, wt. %	±2
Admixtures, wt. or volume %	±3
Water, wt. or volume %	±1

4.6. **Mixing and Delivering Concrete**.

4.6.1. **Mixing Concrete**. Operate mixers and agitators within the limits of the rated capacity and speed of rotation for mixing and agitation as designated by the manufacturer of the equipment. Provide concrete in a thoroughly mixed and uniform mass with a satisfactory degree of uniformity when tested in accordance with Tex-472-A.

Do not top-load new concrete onto returned concrete.

Adjust mixing times and batching operations as necessary when the concrete contains silica fume to ensure the material is completely and uniformly dispersed in the mix. The dispersion of the silica fume within the mix will be verified by the Construction Division, Materials and Pavements Section, using cylinders made from trial batches. Make necessary changes to the batching operations, if uniform dispersion is not achieved, until uniform and complete dispersion of the silica fume is achieved.

Mix concrete by hand methods or in a small motor-driven mixer when permitted, for small placements of less than 2 cu. yd. For such placements, proportion the mix by volume or weight.

4.6.2. **Delivering Concrete**. Deliver concrete to the project in a thoroughly mixed and uniform mass, and discharge the concrete with a satisfactory degree of uniformity. Conduct testing in accordance with Tex-472-A when there is a reason to suspect the uniformity of concrete and as directed.

Maintain concrete delivery and placement rates sufficient to prevent cold joints.

Adding chemical admixtures or the portion of water withheld is only permitted at the jobsite, under the supervision of the Engineer, to adjust the slump or slump flow of the concrete. Do not add water or chemical admixtures to the batch after more than an amount needed to conduct slump testing has been discharged. Turn the drum or blades at least 30 additional revolutions at mixing speed to ensure thorough and uniform mixing of the concrete. When this water is added, do not exceed the approved mix design water-to-cementitious material ratio.

Before unloading, furnish the delivery ticket for the batch of concrete containing the information required on Department Form 596, "Concrete Batch Ticket." The Engineer will verify all required information is provided on the delivery tickets. The Engineer may suspend concrete operations until the corrective actions are implemented if delivery tickets do not provide the required information. The Engineer will verify the design water-to-cementitious material ratio is not exceeded.

Begin the discharge of concrete delivered in truck mixers within the times listed in Table 14. Concrete may be discharged after these times provided the concrete temperature and slump meet the requirements listed in this Item and other pertinent Items. Perform these tests with certified testing personnel per Section 421.4.8.1., "Certification of Testing Personnel." Provide the Engineer the option of witnessing testing of the concrete. If not provided this option, the Engineer may require additional testing before the concrete is placed.

Table 14
Concrete Discharge Times

Fresh Concrete Temperature, °F	Max Time After Batching for Concrete Not Containing Type B or D Admixtures, min.	Max Time After Batching for Concrete Containing Type B or D Admixtures,[1] min.
90 and above	45	75
75 ≤ T < 90	60	90
T < 75	90	120

1. Concrete must contain at least the minimum manufacturer's recommended dosage of Type B or D admixture.

4.7. **Placing, Finishing, and Curing Concrete**. Place, finish, and cure concrete in accordance with the pertinent Items.

4.8. **Sampling and Testing of Concrete**. Unless otherwise specified, all fresh and hardened concrete is subject to testing as follows:

4.8.1. **Certification of Testing Personnel**. Contractor personnel performing testing must be either ACI-certified or qualified by a Department-recognized equivalent written and performance testing program for the tests being performed. Personnel performing these tests are subject to Department approval. Use of a commercial laboratory is permitted at the Contractor's option. All personnel performing testing using the maturity method must be qualified by a training program recognized by the Department before using this method on the job.

4.8.2. **Fresh Concrete**. Provide safe access and assistance to the Engineer during sampling. Fresh concrete will be sampled for testing at the discharge end if using belt conveyors or pumps. When it is impractical to sample at the discharge end, a sample will be taken at the time of discharge from the delivery equipment and correlation testing will be performed and documented to ensure specification requirements are met at the discharge end.

4.8.3. **Testing of Fresh Concrete**. Test for the fresh properties listed in Table 15.

Table 15
Fresh Concrete Tests

Tests	Test Methods
Slump[1]	Tex-415-A
Temperature[1]	Tex-422-A
Air Content[1,2]	Tex-414-A, Tex-416-A, or ASTM C457

1. Job-control testing performed by the Contractor.
2. Only required when air-entrained concrete is specified on the plans.

Concrete with a slump lower than the minimum placement slump in Table 9 after the addition of all water withheld, or concrete exhibiting segregation and excessive bleeding will be rejected.

4.8.3.1. **Job-Control Testing**. Perform job-control testing as specified in Table 16 unless otherwise specified. Provide the Engineer the opportunity to witness the testing. The Engineer may require a retest if not given the opportunity to witness. Immediately notify the Engineer of any nonconformity issues. Furnish a copy of all test results to the Engineer daily.

Table 16
Job-Control Testing Frequencies

Concrete Placements	Frequency
Bridge Deck Placements	Test the first few loads, then every 60 cu. yd. or fraction thereof.
All Other Structural Class Concrete Placements	One test every 60 cu. yd. or fraction thereof per class per day.
Non-Structural Class Concrete Placements	One test every 180 cu. yd. or fraction thereof.

Immediately resample and retest the concrete slump when the concrete exceeds the slump range at time of placement. If the concrete exceeds the slump range after the retest, and is used at the Contractor's option, the Engineer will make strength specimens as specified in Article 421.5., "Acceptance of Concrete."

4.8.3.2. **Strength Specimen Handling**. Remove specimens from their molds and deliver Department test specimens to curing facilities within 24 to 48 hr. after molding, in accordance with pertinent test procedures unless otherwise shown on the plans or directed. Clean and prepare molds for reuse if necessary.

5. ACCEPTANCE OF CONCRETE

The Engineer will sample and test the fresh and hardened concrete for acceptance. The test results will be reported to the Contractor and the concrete supplier. Investigate the quality of the materials, the concrete production operations, and other possible problem areas to determine the cause for any concrete that fails to meet the required strengths as outlined below. Take necessary actions to correct the problem including redesign of the concrete mix. The Engineer may suspend all concrete operations under the pertinent Items if the Contractor is unable to identify, document, and correct the cause of the low strengths in a timely manner. Resume concrete operations only after obtaining approval for any proposed corrective actions. Concrete failing to meet the required strength as outlined below will be evaluated using the procedures listed in Article 421.6., "Measurement and Payment."

5.1. **Structural Class of Concrete**. For concrete classes identified as structural concrete in Table 8, the Engineer will make and test 7-day and 28-day specimens. Acceptance will be based on attaining the design strength given in Table 8.

5.2. **Class P and Class HES**. The Engineer will base acceptance in accordance with Item 360, "Concrete Pavement," and Item 361, "Repair of Concrete Pavement."

5.3. **All Other Classes of Concrete**. For concrete classes not identified as structural concrete in Table 8, the Engineer will make and test 7-day specimens. The Engineer will base acceptance on the 7-day target value established in accordance with Section 421.4.3., "Concrete Trial Batches."

6. MEASUREMENT AND PAYMENT

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

The following procedure will be used to evaluate concrete where one or more project acceptance test specimens fail to meet the required design strength specified in this Item or on the plans:

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

$$A = B_p\left[-5.37\left(\frac{S_a}{S_s}\right)^2 + 11.69\left(\frac{S_a}{S_s}\right) - 5.32\right]$$

where:
A = Amount to be paid per unit of measure for the entire placement in question
S_a = Actual average strength from cylinders or cores. Use values from cores, if taken.
S_s = Minimum required strength (specified)
B_p = Unit Bid Price

- If the structural review determines the concrete is not adequate to remain in service, the Engineer will determine the limits of the concrete to be removed.
- The decision to reject structurally inadequate concrete or to apply the payment adjustment factor will be made no later than 56 days after placement.

Item 422
Concrete Superstructures

1. DESCRIPTION

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

2. MATERIALS

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

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

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

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

- Provide preformed bituminous fiber expansion joint material unless indicated otherwise.
- Provide a Class 4, 5, or 7 low-modulus silicone sealant unless otherwise directed.
- Provide asphalt board that conforms to dimensions shown on the plans.
- Provide re-bonded neoprene filler that conforms to the dimensions shown on the plans.

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

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

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

2.7. **Curing Materials**. Provide membrane curing compounds in accordance with DMS-4650, "Hydraulic Cement Concrete Curing Materials and Evaporation Retardants."

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

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

Provide burlap-polyethylene mats made from burlap impregnated on one side with a film of opaque white pigmented polyethylene, free from visible defects. Provide laminated mats that have at least one layer of an impervious material such as polyethylene, vinyl plastic, or other acceptable material (either as a solid sheet or impregnated into another fabric) and are free of visible defects.

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

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

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

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

3. EQUIPMENT

3.1. **Fogging Equipment**. Use fogging equipment that can apply water in a fine mist, not a spray. Produce the fog using equipment that pumps water or water and air under high pressure through a suitable atomizing nozzle. Use hand-held mechanical equipment portable enough to use in the direction of any prevailing wind and adaptable for intermittent use to prevent excessive wetting of the concrete.

3.2. **Transporting and Placing Equipment**. Use appropriate transporting and placing equipment such as buckets, chutes, buggies, belt conveyors, pumps, or other equipment as necessary. Do not transport or convey concrete through equipment made of aluminum. Use carts with pneumatic tires for carting or wheeling concrete over newly placed slabs.

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

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

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

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

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

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

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

3.7. **Sawing Equipment**. Use sawing equipment capable of cutting grooves in completed bridge slabs and top slabs of direct traffic culverts. Provide grooves that are 1/8 to 3/16 in. deep, nominally 1/8 in. wide, and spaced at 1 in. Use sawing equipment capable of cutting grooves in hardened concrete within 18 in. of the barrier rail or curb.

3.8. **Spraying Equipment**. Use mechanically powered pressure sprayers with appropriate atomizing nozzles for the application of membrane curing. Mechanically driven spraying equipment, adaptable to the rail system used by the screeds, may be used for applying membrane curing to bridge slabs. Use hand-pressurized spray equipment equipped with 2 or 3 fan-spray nozzles if approved. Ensure the spray from each nozzle overlaps the spray from adjacent nozzles by approximately 50%.

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

4. CONSTRUCTION

Obtain approval for proposed construction methods before starting work. Approval of construction methods and equipment does not relieve the Contractor's responsibility for safety or correctness of methods, adequacy of equipment, or completion of work in full accordance with the Contract. Attend the pre-construction (pre-pour) meetings for bridge slabs conducted by the Engineer. Provide and obtain approval for proposed finishing methods, interim curing methods, and final curing methods.

Unless otherwise shown on the plans, it is the Contractor's option to perform testing on structural concrete (structural classes of concrete are identified in Table 8 of Section 421.4.1., "Classification of Concrete Mix Designs,") to determine the in-situ strength to address the schedule restrictions listed below. The Engineer may require the Contractor to perform this testing for concrete placed in cold weather. Make enough test specimens for Contractor-performed testing to ensure strength requirements are met for the operations listed below. Make at least 1 set of test specimens for each element cast each day. Cure these specimens under the same conditions as the portion of the structure involved for all stages of construction. Ensure safe handling, curing, and storage of all test specimens. Provide testing personnel, and sample and test the hardened concrete in accordance with Section 421.4.8., "Sampling and Testing of Concrete." The maturity method, Tex-426-A, may be used for in-situ strength determination for schedule restrictions if approved. Coring will not be allowed for in-situ strength determination for schedule restrictions. Provide the Engineer the opportunity to witness all testing operations. Report all test results to the Engineer.

If the Contractor does not wish to perform schedule restriction testing, the Engineer's 7-day lab-cured tests, performed in accordance with Article 421.5., "Acceptance of Concrete," will be used for schedule restriction determinations. The Engineer may require additional time for strength gain to account for field curing conditions such as cold weather.

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

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

4.1.2. **Longitudinal Screeding of Bridge Slabs**. Place a longitudinal screed directly on previously placed concrete slabs to check and grade an adjacent slab only after the previously placed slab has aged at least 24 hr. Place and screed the concrete after the previously placed slabs have aged at least 48 hr. Maintain curing of the previously placed slabs during placement.

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

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

4.1.4. **Storage of Materials on the Structure**. Obtain approval to store materials on completed portions of a structure once a compressive strength of 3,000 psi has been attained. Maintain proper curing if materials will be stored on structures before completion of curing.

4.1.5. **Placement of Equipment and Machinery**. Do not place erection equipment or machinery on the structure until the concrete has attained the design strength specified in Section 421.4.1., "Classification of Concrete Mix Designs," unless otherwise approved.

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

4.1.7. **Placing Bridge Rails**. Reinforcing steel and concrete for bridge rails may be placed on bridge slabs once the slab concrete has attained a compressive strength of 3,000 psi. Ensure the slab concrete has attained its design strength specified in Section 421.4.1., "Classification of Concrete Mix Designs," before placing railing concrete if slipforming methods are used for railing concrete.

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

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

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

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

4.2. **Forms**. Submit forming plans for decks or slabs on beams or girders, overhangs, cast-in-place spans, and bracing systems for girders when the overhang exceeds 3 ft. 6 in. Submit similar plans for other units of the superstructure as directed. Show all essential details of proposed forms and bracing. Have a licensed professional engineer design, seal, and sign these plans. Department approval is not required, but the Department reserves the right to request modifications to the plans. The Contractor is responsible for the adequacy of these plans.

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

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

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

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

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

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

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

When setting forms of any type take into account:

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

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

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

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

Complete all preparatory work before placing concrete.

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

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

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

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

Use plywood at least 3/4 in. thick. Use plywood for forming surfaces that remain exposed that meets the requirements for B-B Plyform Class I or Class II Exterior of the U.S. Department of Commerce Voluntary Product Standard PS 1.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

4.6.4. **Transporting Concrete**. Use a method and equipment capable of maintaining the rate of placement shown on the plans or required by this Item to transport concrete to the forms. Transport concrete by buckets, chutes, buggies, belt conveyors, pumps, or other methods.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Thoroughly clean the hardened concrete surface of all loose material, laitance, dirt, and foreign matter, and saturate it with water. Remove all free water and moisten the surface before concrete or bonding grout is placed against it. Ensure the surface of the existing concrete is in a saturated surface-dry (SSD) condition just before placing subsequent concrete. Prewet the existing concrete by ponding water on the surface for 24 hr. before placing subsequent concrete. Use high-pressure water blasting to achieve SSD conditions 15 to 30 min. before placing the concrete if ponding is not possible. An SSD condition is achieved when the surface remains damp when exposed to sunlight for 15 min.

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

Bonding agents are not required unless indicated otherwise. Coat the joint surface with bonding mortar, grout, epoxy, or other material as indicated on the plans or other Items if a bonding agent is required. Provide Type V epoxy per DMS-6100, “Epoxies and Adhesives,” for bonding fresh concrete to hardened concrete. Place the bonding epoxy on a clean, dry surface, and place the fresh concrete while the epoxy is still tacky. Place bonding mortar or grout on a surface that is SSD, and place the concrete before the bonding mortar or grout dries. Place other bonding agents in accordance with the manufacturer’s recommendations.

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

Do not allow concrete to free-fall more than 5 ft. Remove any hardened concrete splatter ahead of the plastic concrete.

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

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

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

Vibrate the concrete immediately after deposit. Systematically space points of vibration to ensure complete consolidation and thorough working of the concrete around the reinforcement, embedded fixtures, and into the corners and angles of the forms. Insert the vibrator vertically where possible except for slabs where it may be inserted in a sloping or horizontal position. Vibrate the entire depth of each lift, allowing the vibrator to penetrate several inches into the preceding lift. Do not use the vibrator to move the concrete to other locations in the forms. Do not drag the vibrator through the concrete. Thoroughly consolidate concrete along construction joints by operating the vibrator along and close to but not against the joint surface. Continue the vibration until the concrete surrounding reinforcements and fixtures is completely consolidated. Hand-spade or rod the concrete if necessary to ensure flushing of mortar to the surface of all forms. Concentrate vibration efforts along the beams lines when precast concrete panels are used for deck construction.

4.6.10. **Installation of Dowels and Anchor Bolts**. Install dowels and anchor bolts by casting them in-place or by grouting with grout, epoxy, or epoxy mortar unless noted otherwise. Form or drill holes for grouting. Use only epoxy when installing horizontal dowels into the edges of slabs. Follow the manufacturer's recommended installation procedures for pre-packaged grout or epoxy anchor systems. Test anchors if required on the plans or by other Items.

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

Thoroughly clean holes of all loose material, oil, grease, or other bond-breaking substance, and blow them clean with filtered compressed air. Use a wire brush followed by oil-free compressed air to remove all loose material from the holes, repeating as necessary until no more material is removed. Ensure holes are in a surface-dry condition when epoxy type materials are used and in a surface-moist condition when cementitious grout is used. Develop and demonstrate for approval a procedure for cleaning and preparing the holes for installation of the dowels and anchor bolts. Completely fill the void between the hole and dowel or bolt with grouting material. Follow exactly the requirements for cleaning outlined in the product specifications for pre-packaged systems.

Provide a Type III epoxy per DMS-6100, "Epoxies and Adhesives," when neat epoxy is used for anchor bolts or dowels. Provide Type VIII epoxy per DMS-6100, "Epoxies and Adhesives," when an epoxy grout is used. Provide grout, epoxy, or epoxy mortar as the binding agent unless otherwise indicated on the plans.

Provide other anchor systems as required on the plans.

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

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

Provide and install recording thermometers, maturity meters, or other suitable temperature measuring devices to verify all concrete is effectively protected. Maintain the temperature of the top surface of bridge slabs and top slabs of direct traffic culverts at 50°F or above for 72 hr. from the time of placement and above 40°F for an additional 72 hr.

Use additional covering, insulated forms, or other means and, if necessary, supplement the covering with artificial heating. Avoid applying heat directly to concrete surfaces. Cure as specified in Section 422.4.8., "Final Curing," during this period until all requirements for curing have been satisfied.

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

4.6.12. **Placing Concrete in Hot Weather**. Use an approved Type B or D set retarding agent in all concrete for superstructures and top slabs of direct traffic culverts, except concrete containing slag cement, when the temperature of the air is above 85°F unless otherwise directed.

Keep the concrete at or below the maximum temperature at time of placement as specified above. Sprinkle and shade aggregate stockpiles or use ice, liquid nitrogen systems, or other approved methods as necessary to control the concrete temperature.

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

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

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

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

Level, strike off, and screed the surface while carrying a slight excess of concrete ahead of the screed to fill all low spots as soon as the concrete has been placed and vibrated in a section wide enough to permit working. Move longitudinal screeds across the concrete with a saw-like motion while their ends rest on headers or templates set true to the roadway grade or on the adjacent finished slab. Move transverse screeds longitudinally approximately 1/5 of the drum length for each complete out-and-back pass of the carriage. Screed the surface of the concrete enough times and at intervals to produce a uniform surface true to grade and free of voids.

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

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

4.6.13.1. **Transverse Screeding**. Install rails for transverse finishing machines that are supported from the beams or girders so the supports may be removed without damage to the slab. Prevent bonding between removable supports and the concrete in an acceptable manner. Do not allow rail support parts that remain embedded in the slab to project above the upper mat of reinforcing steel. Rail or screed supports attached to I-beams or girders are subject to the requirements of this Item. Place concrete at a minimum rate of 30 ft. of bridge slab per hour for transverse screeding unless otherwise shown on the plans. Deposit concrete parallel to the skew of the bridge so all girders are loaded uniformly along their length. Deposit slab concrete between the exterior beam and adjacent beam before placing concrete in the overhang portion of the slab. Furnish personnel and equipment capable of placing, finishing, and curing the slab at an acceptable rate to ensure compliance with the specifications. Place concrete in transverse strips. Start placement at the lowest end on profile grades greater than 1-1/2%.

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

4.6.13.2. **Longitudinal Screeding**. Use of temporary intermediate headers will be permitted for placements over 50 ft. long if the rate of placement is rapid enough to prevent a cold joint and if these headers are designed for easy removal to permit satisfactory consolidation and finish of the concrete at their locations unless otherwise shown on the plans. Deposit slab concrete between the exterior beam and the adjacent beam before placing concrete in the overhang portion of the slab. Place concrete in longitudinal strips starting at a point in the center of the segment adjacent to 1 side except as this Section indicates, and complete the strip by placing uniformly in both directions toward the ends. Start placing at the lowest end for spans on a profile grade of 1-1/2% or more. Use strips wide enough that the concrete within each strip remains plastic until placement of the adjacent strip. Place the concrete in proper sequence to be monolithic with the adjacent longitudinal strips of the slabs where monolithic curb construction is specified.

4.6.13.3. **Placements on Continuous Steel Units**. Place slabs on continuous steel units in a single, continuous operation without transverse construction joints using a self-propelled transverse finishing machine or a mechanical longitudinal screed unless otherwise shown on the plans. Retard the initial set of the concrete sufficiently to ensure concrete remains plastic in at least 3 spans immediately preceding the slab being placed. Use construction joints, when required for slab placements on steel beams or girders, as shown on the plans. Ensure the previously placed concrete attains a compressive strength of 3,000 psi when staged placement of a slab is required on the plans before placing the next stage concrete. Multiple stages may be placed in a single day if approved. Use an approved placing sequence that will not overstress any of the supporting members where plans permit staged placing without specifying a particular order of placement.

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

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

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

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

Perform sufficient checks, witnessed by the Engineer, with a long-handled 10-ft. straightedge on the plastic concrete to ensure the final surface will be within specified tolerances. Make the check with the straightedge parallel to the centerline. Lap each pass half over the preceding pass. Remove all high spots, and fill and float all depressions over 1/16 in. deep with fresh concrete. Continue checking and floating until the surface is true to grade and free of depressions, high spots, voids, or rough spots. Fill screed-rail support holes with concrete, and finish them to match the top of the slab.

Provide a uniform micro-texture using a carpet drag, burlap drag, or broom finish. Finish the surface to a smooth sandy texture without blemishes, marks, or scratches deeper than 1/16 in. Apply the surface texturing using a work bridge or platform immediately after completing the straightedge checks. Draw the carpet or burlap drag longitudinally along the concrete surface, adjusting the surface contact area or pressure to provide a satisfactory coarsely textured surface. A broom finish may be performed using a fine bristle broom transversely. For bridge approach slabs the carpet drag, burlap drag, or broom finish may be applied either longitudinally or transversely.

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

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

4.7.1.1. **Evaporation Retardant**. Coat the concrete surface immediately after the carpet or burlap drag, or broom finish with a single application of evaporation retardant at a rate recommended by the manufacturer. Do not allow more than 10 min. to elapse between the texturing at any location and application of evaporation retardant. The evaporation retardant may be applied using the same work bridge used for surface texturing. Do not work the concrete surface once the evaporation retardant has been applied.

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

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

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

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

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

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

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

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

Place polyethylene sheeting, burlap-polyethylene blankets, laminated mats, or insulating curing mats in direct contact with the slab when the air temperature is expected to drop below 40°F during the first 72 hr. of the curing period. Weigh down these curing materials with dry mats to maintain direct contact with the concrete and provide insulation against cold weather. Supplemental heating or insulation may be required in cold and wet weather if the insulating cotton mats become wet or the concrete drops below the specified curing temperature. Avoid applying heat directly to concrete surfaces.

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

4.8.1. **Cotton Mats**. Keep the concrete continuously wet by maintaining wet cotton mats in direct contact with the concrete for the required curing time. Weight the mats adequately to provide continuous contact with all concrete. Cover surfaces that cannot be cured by direct contact with mats, forming an enclosure well anchored to the forms or ground so outside air cannot enter the enclosure. Provide sufficient moisture inside the enclosure to keep all surfaces of the concrete wet. Use of soaker hoses and plastic covering is acceptable provided the concrete surface remains continuously wet for the required curing duration.

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

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

4.9. **Removal of Forms and Falsework**. Forms for vertical surfaces may be removed after the concrete has aged 12 hr. after initial set provided the removal can be done without damage to the concrete unless otherwise directed.

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

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

Forms or parts of forms may be removed only if constructed to permit removal without disturbing forms or falsework required to be left in place for a longer period on other portions of the structure.

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

Remove all forms and falsework unless otherwise directed.

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

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

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

Repair defective work as soon as possible. Remove and replace at the expense of the Contractor any defect that cannot be repaired to the satisfaction of the Engineer.

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

4.11. **Final Surface Texture**. Saw-cut grooves in the hardened concrete of bridge slabs, bridge approach slabs, and direct traffic culverts to produce the final texturing after completion of the required curing period unless otherwise noted. Cut grooves perpendicular to the structure centerline. Cut grooves across the slab within 18 in. of the barrier rail, curb, or median divider. Adjust groove cutting at skewed metal expansion joints in bridge slabs by using narrow-width cutting heads so all grooves end within 6 in. of the joint, measured perpendicular to the centerline of the metal joint. Leave no ungrooved surface wider than 6 in. adjacent to either side of the joint. Ensure the minimum distance to the first groove, measured perpendicular to the edge of the concrete joint or from the junction between the concrete and the metal leg of the joint, is 1 in. Cut grooves continuously across construction joints or other joints in the concrete less than 1/2 in. wide. Apply the same procedure described above where barrier rails, curbs, or median dividers are not parallel to the structure centerline to maintain the 18 in. maximum dimension from the end of the grooves to the gutter line. Cut grooves continuously across formed concrete joints. Provide either a carpet drag or broom finish for micro-texture when saw-cut grooves are not required on the plans. In this case ensure an adequate and consistent micro-texture is achieved by applying enough weight to the carpet and keeping the carpet or broom from getting plugged with grout. For surfaces that do not have adequate texture, the Engineer may require corrective action including diamond grinding or shot blasting.

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

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

5. MEASUREMENT

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

Approach slabs and cast-in-place superstructure elements including flat slabs, slab and girder units (pan formed), and shear keys will be measured by the cubic yard. For slab and girder spans using pan forms, a quantity will be included for the screed setting required to provide proper camber in the roadway surface after form removal.

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

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

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

6. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for the various superstructure elements specified. This price is full compensation for furnishing, hauling, mixing, placing, curing, and finishing concrete; furnishing and placing reinforcing steel; grouting and pointing; furnishing and placing drains and expansion joint material (except where specifically furnished under another Item); furnishing and placing metal flashing strips; forms (removable and permanent) and falsework; prestressed concrete panels; furnishing and placing concrete and reinforcement for raised medians, sidewalks, sign mounts, luminaire brackets, and other concrete appurtenances; removing designated portions of existing slab; cleaning, bending, and cutting exposed existing reinforcing steel; welding reinforcing steel; doweling; cleaning and preparing concrete surfaces; and equipment, labor, tools, and incidentals.

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

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

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

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

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

Item 423
Retaining Walls

1. DESCRIPTION

Furnish, construct, and install retaining walls.

2. MATERIALS

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

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

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

Table 1
Concrete for Retaining Walls

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

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

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

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

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

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

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

2.3. **Fabrication**.

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

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

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

2.4. **Backfill**.

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

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

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

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

Table 2
Select Backfill Gradation Limits

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

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

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

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

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

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

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

Table 3
Drainage Aggregate Gradation Limits

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

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

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

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

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

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

3. CONSTRUCTION

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

4. MEASUREMENT

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

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

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Retaining Walls" of the type or special surface finish specified. This price is full compensation for excavation in back of retaining walls and for footings; furnishing and placing footings, leveling pads, copings, and traffic railing foundations; furnishing, placing, and compacting backfill (except in embankment areas), including cement for stabilization; proof rolling; furnishing and placing concrete, reinforcing steel, waterproofing material, filter material and drain pipe, joint material, water stop, and filter fabric when required; fabricating, curing, and finishing all panels; furnishing and placing earth reinforcement, anchorage systems, and fasteners; wall erection; and equipment, labor, tools, and incidentals.

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

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

Item 432
Riprap

1. DESCRIPTION

Furnish and place concrete, stone, cement-stabilized, or special riprap.

2. MATERIALS

Furnish materials in accordance with the following Items.

- Item 420, "Concrete Substructures,"
- Item 421, "Hydraulic Cement Concrete,"
- Item 431, "Pneumatically Placed Concrete,"
- Item 440, "Reinforcement for Concrete," and
- DMS-6200, "Filter Fabric."

2.1. **Concrete Riprap**. Use Class B Concrete unless otherwise shown on the plans.

2.2. **Pneumatically Placed Concrete Riprap**. Use Class II concrete that meets Item 431, "Pneumatically Placed Concrete," unless otherwise shown on the plans.

2.3. **Stone Riprap**. Use durable natural stone with a bulk specific gravity of at least 2.50 as determined by Tex-403-A unless otherwise shown on the plans. Provide stone that, when tested in accordance with Tex-411-A, has weight loss of no more than 18% after 5 cycles of magnesium sulfate solution.

Perform a size verification test on the first 5,000 sq. yd. of finished riprap stone for all types of stone riprap at a location determined by the Engineer. Test the riprap stone in accordance with ASTM D5519. Additional tests may be required. Do not place additional riprap until the initial 5,000 sq. yd. of riprap has been approved.

Provide grout or mortar in accordance with Item 421, "Hydraulic Cement Concrete," when specified. Provide grout with a consistency that will flow into and fill all voids.

Provide filter fabric in accordance with DMS-6200, "Filter Fabric." Provide Type 2 filter fabric for protection stone riprap unless otherwise shown on the plans. Provide Type 2 filter fabric for Type R, F, or Common stone riprap when shown on the plans.

2.3.1. **Type R**. Use stones between 50 and 250 lb. with at least 50% of the stones heavier than 100 lb.

2.3.2. **Type F**. Use stones between 50 and 250 lb. with at least 40% of the stones heavier than 100 lb. Use stones with at least 1 broad flat surface.

2.3.3. **Common**. Use stones between 50 and 250 lb. Use stones that are at least 3 in. in their least dimension. Use stones that are at least twice as wide as they are thick. When shown on the plans or approved, material may consist of broken concrete removed under the Contract or from other approved sources. Cut exposed reinforcement flush with all surfaces before placement of each piece of broken concrete.

2.3.4. **Protection**. Use boulders or quarried rock that meets the gradation requirements of Table 1. Both the width and the thickness of each piece of riprap must be at least 1/3 of the length. When shown on the plans or as approved, material may consist of broken concrete removed under the Contract or from other approved sources. Cut exposed reinforcement flush with all surfaces before placement of each piece of broken

concrete. Determine gradation of the finished, in-place, riprap stone under the direct supervision of the Engineer in accordance with ASTM D5519.

Table 1
In-Place Protection Riprap Gradation Requirements

Size	Maximum Size (lb.)	90% Size[1] (lb.)	50% Size[2] (lb.)	8% Size[3] Minimum (lb.)
12 in.	200	80–180	30–75	3
15 in.	320	170–300	60–165	20
18 in.	530	290–475	105–220	22
21 in.	800	460–720	175–300	25
24 in.	1,000	550–850	200–325	30
30 in.	2,600	1,150–2,250	400–900	40

1. Defined as that size such that 10% of the total riprap stone, by weight, is larger and 90% is smaller.
2. Defined as that size such that 50% of the total riprap stone, by weight, is larger and 50% is smaller.
3. Defined as that size such that 92% of the total riprap stone, by weight, is larger and 8% is smaller.

The Engineer may require in-place verification of the stone size. Determine the in-place size of the riprap stone by taking linear transects along the riprap and measuring the intermediate axis of the stone at select intervals. Place a tape measure along the riprap and determine the intermediate axis size of the stone at 2 ft. intervals. Measure a minimum of 100 stones, either in a single transect or in multiple transects, then follow ASTM D5519 Test Procedure Part B to determine the gradation. Table 2 is a guide for comparing the stone size in inches to the stone weight shown in Table 1.

Table 2
Protection Riprap Stone Size[1]

Size	Dmax (in.)	D90 (in.)	D50 (in.)	D8 (in.)
12 in.	13.76	10.14–13.29	7.31–9.92	3.39
15 in.	16.10	13.04–15.75	9.21–12.91	6.39
18 in.	19.04	15.58–18.36	11.10–14.21	6.59
21 in.	21.85	18.17–21.09	13.16–15.75	6.88
24 in.	23.53	19.28–22.29	13.76–16.18	7.31
30 in.	32.36	24.65–30.84	17.34–22.72	8.05

1. Based on a Specific Gravity of 2.5 and using the following equation for the intermediate axis diameter $D = \{(12*W)/(Gs*62.4*0.85)\}^{1/3}$

   where:
   D = intermediate axis diameter in in.;
   W = weight of stone in lbs.;
   Gs = Specific Gravity of stone.
   Note—If the Specific Gravity of the stone is different than 2.5, then the above equation can be used to determine the appropriate size using the actual Specific Gravity.

If required, provide bedding stone that, in-place, meets the gradation requirements shown in Table 3 or as otherwise shown on the plans. Determine the size distribution in Table 3 in accordance with ASTM D6913.

Table 3
Protection Riprap Bedding Material Gradation Requirements

Sieve Size (Sq. Mesh)	% by Weight Passing
3"	100
1-1/2"	50–80
3/4"	20–60
#4	0–15
#10	0–5

2.4. **Cement-Stabilized Riprap**. Provide aggregate that meets Item 247, “Flexible Base,” for the type and grade shown on the plans. Use cement-stabilized riprap with 7% hydraulic cement by dry weight of the aggregate.

2.5. **Special Riprap**. Furnish materials for special riprap according to the plans.

3. CONSTRUCTION

Dress slopes and protected areas to the line and grade shown on the plans before the placement of riprap. Place riprap and toe walls according to details and dimensions shown on the plans or as directed.

3.1. **Concrete Riprap**. Reinforce concrete riprap with 6 × 6 – W2.9 × W2.9 welded wire fabric or with No. 3 or No. 4 reinforcing bars spaced at a maximum of 18 in. in each direction unless otherwise shown. Alternative styles of welded wire fabric that provide at least 0.058 sq. in. of steel per foot in both directions may be used if approved. A combination of welded wire fabric and reinforcing bars may be provided when both are permitted. Provide a minimum 6-in. lap at all splices. Provide horizontal cover of at least 1 in. and no more than 3 in. at the edge of the riprap. Place the first parallel bar no more than 6 in. from the edge of concrete. Use approved supports to hold the reinforcement approximately equidistant from the top and bottom surface of the slab. Adjust reinforcement during concrete placement to maintain correct position.

Sprinkle or sprinkle and consolidate the subgrade before the concrete is placed as directed. All surfaces must be moist when concrete is placed.

Compact and shape the concrete once it has been placed to conform to the dimensions shown on the plans. Finish the surface with a wood float after it has set sufficiently to avoid slumping to secure a smooth surface or broom finish as approved.

Cure the riprap immediately after the finishing operation according to Item 420, “Concrete Substructures.”

3.2. **Stone Riprap**. Provide the following types of stone riprap when shown on the plans:

- **Dry Riprap**. Stone riprap with voids filled with only spalls or small stones.
- **Grouted Riprap**. Type R, F, or Common stone riprap with voids grouted after all the stones are in place.
- **Mortared Riprap**. Type F stone riprap laid and mortared as each stone is placed.

Use spalls and small stones lighter than 25 lb. to fill open joints and voids in stone riprap, and place to a tight fit.

Place mortar or grout only when the air temperature is above 35°F. Protect work from rapid drying for at least 3 days after placement.

Place filter fabric with the length running up and down the slope unless otherwise approved. Ensure fabric has a minimum overlap of 2 ft. Secure fabric with nails or pins. Use nails at least 2 in. long with washers or U-shaped pins with legs at least 9 in. long. Space nails or pins at a maximum of 10 ft. in each direction and 5 ft. along the seams. Alternative anchorage and spacing may be used when approved.

3.2.1. **Type R**. Construct riprap as shown in Figure 1 on the *Stone Riprap Standard* and as shown on the plans. Place stones in a single layer with close joints so most of their weight is carried by the earth and not the adjacent stones. Place the upright axis of the stones at an angle of approximately 90° to the embankment slope. Place each course from the bottom of the embankment upward with the larger stones in the lower courses.

Fill open joints between stones with spalls. Place stones to create a uniform finished top surface. Do not exceed a 6-in. variation between the tops of adjacent stones. Replace, embed deeper, or chip away stones that project more than the allowable amount above the finished surface.

Prevent earth, sand, or foreign material from filling the spaces between the stones when the plans require Type R stone riprap to be grouted. Wet the stones thoroughly after they are in place, fill the spaces between the stones with grout, and pack. Sweep the surface of the riprap with a stiff broom after grouting.

3.2.2. **Type F**.

3.2.2.1. **Dry Placement**. Construct riprap as shown in Figure 2 on the *Stone Riprap Standard*. Set the flat surface on a prepared horizontal earth bed, and overlap the underlying course to secure a lapped surface. Place the large stones first, roughly arranged in close contact. Fill the spaces between the large stones with suitably sized stones placed to leave the surface evenly stepped and conforming to the contour required. Place stone to drain water down the face of the slope.

3.2.2.2. **Grouting**. Construct riprap as shown in Figure 3 on the *Stone Riprap Standard*. Size, shape, and lay large flat-surfaced stones to produce an even surface with minimal voids. Place stones with the flat surface facing upward parallel to the slope. Place the largest stones near the base of the slope. Fill spaces between the larger stones with stones of suitable size, leaving the surface smooth, tight, and conforming to the contour required. Place the stones to create a plane surface with a variation no more than 6 in. in 10 ft. from true plane. Provide the same degree of accuracy for warped and curved surfaces. Prevent earth, sand, or foreign material from filling the spaces between the stones. Wet the stones thoroughly after they are in place, fill the spaces between them with grout, and pack. Sweep the surface with a stiff broom after grouting.

3.2.2.3. **Mortaring**. Construct riprap as shown in Figure 2 on the *Stone Riprap Standard*. Lap courses as described for dry placement. Wet the stones thoroughly before placing mortar. Bed the larger stones in fresh mortar as they are being place and shove adjacent stones into contact with one another. Spread excess mortar forced out during placement of the stones uniformly over them to fill all voids completely. Point up all joints roughly either with flush joints or shallow, smooth-raked joints as directed.

3.2.3. **Common**. Construct riprap as shown in Figure 4 on the *Stone Riprap Standard*. Place stones on a bed excavated for the base course. Bed the base course of stone well into the ground with the edges in contact. Bed and place each succeeding course in even contact with the preceding course. Use spalls and small stones to fill any open joints and voids in the riprap. Ensure the finished surface presents an even, tight surface, true to the line and grades of the typical sections.

Prevent earth, sand, or foreign material from filling the spaces between the stones when the plans require grouting common stone riprap. Wet the stones thoroughly after they are in place; fill the spaces between them with grout; and pack. Sweep the surface with a stiff broom after grouting.

3.2.4. **Protection**. Construct riprap as shown in Figure 5 on the *Stone Riprap Standard*. Place riprap stone on the slopes within the limits shown on the plans. Place stone for riprap on the filter fabric to produce a reasonably well-graded mass of riprap with the minimum practicable percentage of voids. Construct the riprap to the lines and grades shown on the plans or staked in the field. A tolerance of +6 in. and −0 in. from the slope line and grades shown on the plans is allowed in the finished surface of the riprap. Place riprap to its full thickness in a single operation. Avoid displacing the filter fabric. Ensure the entire mass of stones in their final position is free from objectionable pockets of small stones and clusters of larger stones. Do not place riprap in layers, and do not place it by dumping it into chutes, dumping it from the top of the slope, pushing it from the top of the slope, or any method likely to cause segregation of the various sizes. Obtain the desired distribution of the various sizes of stones throughout the mass by selective loading of material at the quarry or other source or by other methods of placement that will produce the specified results. Rearrange individual stones by mechanical equipment or by hand if necessary to obtain a reasonably well-graded distribution of stone sizes. Use the bedding thickness shown and place stone for riprap on the bedding material to produce a reasonably well-graded mass of riprap with the minimum practicable percentage of voids if required on the plans.

3.3. **Pneumatically Placed Concrete Riprap, Class II**. Meet Item 431, “Pneumatically Placed Concrete.” Provide reinforcement following the details on the plans and Item 440, “Reinforcement for Concrete.” Support reinforcement with approved supports throughout placement of concrete.

Give the surface a wood-float finish or a gun finish as directed. Cure the riprap with membrane-curing compound immediately after the finishing operation in accordance with Item 420, “Concrete Substructures.”

3.4. **Cement-Stabilized Riprap**. Follow the requirements of the plans and the provisions for concrete riprap except when reinforcement is not required. The Engineer will approve the design and mixing of the cement-stabilized riprap.

3.5. **Special Riprap**. Construct special riprap according to the plans.

4. MEASUREMENT

This Item will be measured by the cubic yard of material complete in place. Volume will be computed on the basis of the measured area in place and the thickness and toe wall width shown on the plans.

If required on the plans, the pay quantity of the bedding material for stone riprap for protection to be paid for will be measured by the cubic yard as computed from the measured area in place and the bedding thickness 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 "Riprap" of the type, thickness, and void-filling technique (Dry, Grout, Mortar) specified, as applicable. This price is full compensation for furnishing, hauling, and placing riprap and for filter fabric, expansion joint material, concrete and reinforcing steel, grout and mortar, scales, test weights, equipment, labor, tools, and incidentals.

Payment for excavation of toe wall trenches, for all necessary excavation below natural ground or bottom of excavated channel, and for shaping of slopes for riprap will be included in the unit price bid per cubic yard of riprap.

When bedding is required for protection stone riprap, payment will be made at the unit price for "Bedding Material" of the thickness specified. This price is full compensation for furnishing, hauling, placing, and maintaining the bedding material until placement of the riprap cover is completed and accepted; excavation required for placement of bedding material; and equipment, scales, test weights, labor, tools, and incidentals. No payment will be made for excess thickness of bedding nor for material required to replace embankment material lost by rain wash, wind erosion, or otherwise.

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.

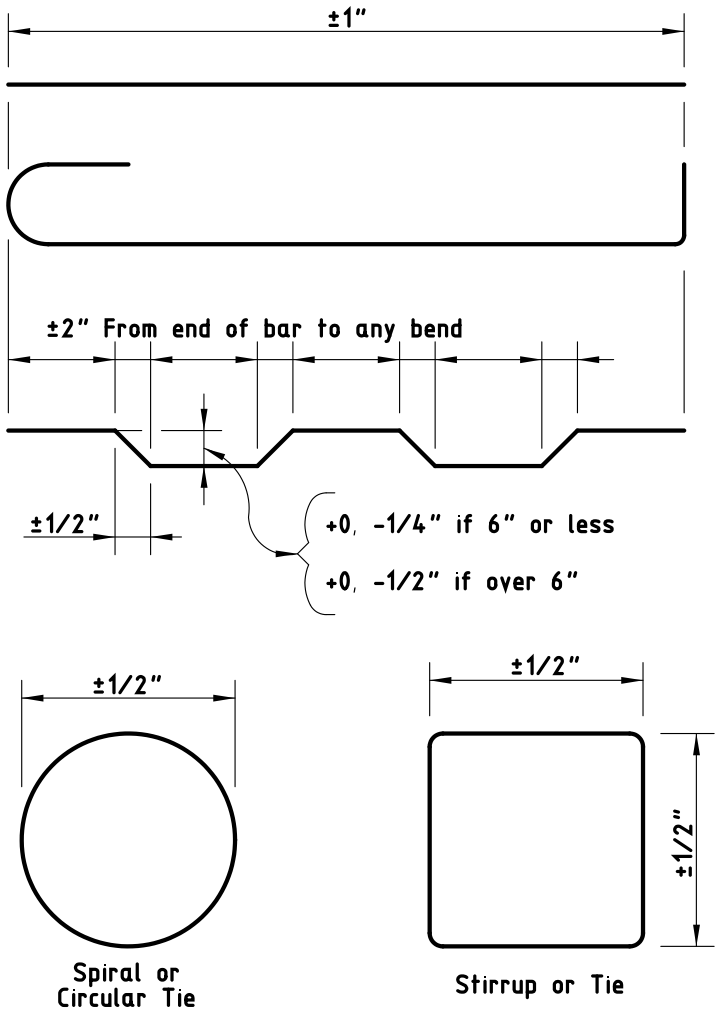


Figure 1
Fabrication Tolerances for Bars

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 441
Steel Structures

1. DESCRIPTION

Fabricate and erect structural steel and other metals used for steel structures or for steel portions of structures.

2. MATERIALS

2.1. **Base Metal**. Use metal that meets Item 442, "Metal for Structures."

2.2. **Approved Electrodes and Flux-Electrode Combinations**. Use only electrodes and flux-electrode combinations found on the Department's MPL. To request a product be added to this list or to renew an expired approval, electronically submit a current Certificate of Conformance containing all tests required by the applicable AWS A5 specification according to the applicable welding code (for most construction, AASHTO/AWS D1.5, *Bridge Welding Code*, or AWS D1.1*, Structural Welding Code—Steel*) to the Construction Division.

2.3. **High-Strength Bolts**. Use fasteners that meet Item 447, "Structural Bolting." Use galvanized fasteners on field connections of bridge members when ASTM A325 bolts are specified and steel is painted.

2.4. **Paint Systems**. Provide the paint system (surface preparation, primer, intermediate, and appearance coats as required) shown on the plans. Provide System IV if no system is specified.

2.4.1. **Standard Paint Systems**. Standard paint systems for painting new steel include the following:

2.4.1.1. **System III-B**. Provide paint in accordance with DMS-8101, "Structural Steel Paints-Performance." Provide inorganic zinc (IOZ) prime coat, epoxy intermediate coat, and urethane appearance coat for all outer surfaces except those to be in contact with concrete. Provide epoxy zinc prime coat for touchup of IOZ.

2.4.1.2. **System IV**. Provide paint in accordance with DMS-8101, "Structural Steel Paints-Performance." Provide IOZ prime coat and acrylic latex appearance coat for all outer surfaces except those to be in contact with concrete. Provide epoxy zinc prime coat for touchup of IOZ.

2.4.2. **Paint Inside Tub Girders and Closed Boxes**. Provide a white polyamide cured epoxy for all interior surfaces, including splice plate but excluding the faying surfaces, unless otherwise shown on the plans. Provide IOZ primer meeting the requirements of DMS-8101, "Structural Steel Paints—Performance," to all interior faying surfaces and splice plates.

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

2.4.4. **Galvanizing**. Provide galvanizing, as required, in accordance with Item 445, "Galvanizing."

2.4.5. **Paint over Galvanizing**. Paint over galvanized surfaces, when required, in accordance with Item 445, "Galvanizing."

2.4.6. **Field Painting**. Provide field paint, as required, in accordance with Item 446, "Field Cleaning and Painting Steel."

3. CONSTRUCTION

3.1. **General Requirements**.

3.1.1. **Applicable Codes**. Perform all fabrication of bridge members in accordance with AASHTO/NSBA Steel Bridge Collaboration S2.1. Follow all applicable provisions of the appropriate AWS code (D1.5 or D1.1) except as otherwise noted on the plans or in this Item. Weld sheet steel (thinner than 1/8 in.) in accordance with ANSI/AWS D1.3, Structural Welding Code—Sheet Steel. Unless otherwise stated, requirements of this Item are in addition to the requirements of S2.1 for bridge members. Follow the more stringent requirement in case of a conflict between this Item and S2.1. Perform all bolting in accordance with Item 447, "Structural Bolting."

Fabricate railroad underpass structures in accordance with the latest AREMA *Manual for Railway Engineering* and this Item. In the case of a conflict between this Item and the AREMA manual, the more stringent requirements apply.

3.1.2. **Notice of Fabrication**. Give adequate notice before commencing fabrication work as specified in Table 1. Include a schedule for all major fabrication processes and dates when inspections are to occur.

Table 1
Notice of Beginning Work

Plant Location	Notice Required
In Texas	7 days
In the contiguous United States	21 days
Outside the contiguous United States	60 days

Perform no Department work in the plant before the Engineer authorizes fabrication. The Contractor must bear all Department travel costs when changes to their fabrication or inspection schedules are not adequately conveyed to the Department.

When any structural steel is fabricated outside of the contiguous 48 states, the additional cost of inspection will be in accordance with Article 6.4., "Sampling, Testing, and Inspection."

3.1.3. **Bridge Members**. Primary bridge members include:

- web and flanges of plate, tub, and box girders;
- rolled beams and cover plates;
- floor beam webs and flanges;
- arch ribs and arch tie beams or girders;
- truss members;
- diaphragm members for curved plate girders or beams;
- pier diaphragm members for tub girders;
- splice plates for primary members; and
- any other member designated as "primary" or "main" on the plans.

Secondary bridge members include:

- bracing (diaphragms, cross frames, and lateral bracing); and
- all other miscellaneous bridge items not considered primary bridge members.

3.1.4. **Responsibility**. The Contractor is responsible for the correctness and completeness of shop drawings and for the fit of shop and field connections.

3.1.5. **Qualification of Plants and Personnel**.

3.1.5.1. **Plants**. Fabrication plants that produce bridge members must be approved in accordance with DMS-7370, "Steel Bridge Member Fabrication Plant Qualification." The Department's MPL has a list of approved bridge member fabrication plants.

Fabrication plants that produce non-bridge steel members listed below must be approved in accordance with DMS-7380, "Steel Non-Bridge Member Fabrication Plant Qualification." The Construction Division maintains a list of approved non-bridge fabrication plants for the following items:

- Roadway Illumination Poles,
- High Mast Illumination Poles,
- High Mast Rings and Support Assemblies,
- Overhead Sign Support Structures,
- Traffic Signal Poles, and
- Intelligent Transportation System (ITS) Poles

The Department will evaluate non-bridge member fabrication plants for competence of the plant, equipment, organization, experience, knowledge, and personnel to produce acceptable work.

3.1.5.2. **Personnel**. Provide a QC staff qualified in accordance with the applicable AWS code. Provide an adequate number of qualified QC personnel for each specific production operation. QC must be on-site and independent of production personnel, as the Engineer determines. QC personnel must be proficient in utilizing the applicable plans, specifications, and test methods, and in verifying compliance with the plant QC and production procedures. Welding inspectors must be current AWS Certified Welding Inspectors for bridge member plants, and for non-bridge member plants requiring Department approval per DMS-7380, "Steel Non-Bridge Member Fabrication Plant Qualification." The QC staff must provide inspection of all materials and workmanship before the Department's inspection. Provide the Department inspector with adequate personnel and equipment needed to move material for inspection access. QC is solely the Contractor's responsibility.

3.1.5.3. **Nondestructive Testing (NDT)**. Personnel performing NDT must be qualified in accordance with the applicable AWS code and the employer's Written Practice. Level III personnel who qualify AS Level I and Level II inspectors must be certified by ASNT for which the NDT Level III is qualified. Testing agencies and individual third-party contractors must also successfully complete periodic audits for compliance, performed by the Department. In addition, ultrasound technicians must pass a hands-on test the Construction Division administers. This will remain current provided they continue to perform testing on Department materials as evidenced by test reports requiring their signature. A technician who fails the hands-on test must wait 6 months before taking the test again. Qualification to perform ultrasonic testing will be revoked when the technician's employment is terminated or when the technician goes 6 months without performing a test on a Department project. The technician must pass a new hands-on test to be re-certified.

3.1.5.4. **Welding Procedure Specifications Qualification Testing**. For bridge member fabrication, laboratories performing welding procedure specifications (WPSs) qualified by testing must be approved in accordance with DMS-7360, "Qualification Procedure for Laboratories Performing Welding Procedure Qualification Testing." The Department's MPL has a list of laboratories approved to perform WPS qualification testing.

3.1.6. **Drawings**.

3.1.6.1. **Erection Drawings**. Submit erection drawings prepared by a licensed professional engineer, including calculations, for approval in accordance with Item 5, "Control of the Work," at least 4 weeks before erecting any portion of field-spliced (welded or bolted) girders, railroad underpasses, trusses, arches, or other members for which erection drawings are required on the plans. Include drawings and calculations for any temporary structures used to support partially erected members. Erection drawings are not required for rolled I-beam units unless otherwise noted on the plans.

Prepare erection drawings following the procedures outlined in Section 2.2 of the AASHTO/NSBA Steel Bridge Collaboration S10.1. As a minimum, include:

- plan of work area showing structure location relative to supports and all obstructions;
- equipment to be used including allowable load information;
- erection sequence for all pieces;
- member weights and center of gravity location of pieces to be lifted;
- locations of cranes, holding cranes, and temporary supports (falsework), including when to release load from temporary supports and holding cranes;
- details of falsework including specific bracing requirements with maximum allowable design wind speed clearly indicated;
- girder lifting points;
- diaphragm and bracing requirements; and
- minimum connection requirements when more than the standard requirements.

Perform girder erection analyses using UT-Lift and UT-Bridge software available on the Department's website or other suitable commercial software. Ensure temporary stresses in members being erected will not cause permanent damage and that stability is maintained throughout the erection operations. Provide actual input files and output results from UT-Lift and UT-Bridge, or graphical and hard copy results from commercial software programs.

Do not proceed if site conditions differing from those depicted on the approved erection drawings could affect temporary support stresses, erected girders, or public safety in any manner. Revise erection drawings and resubmit to the Engineer for approval before proceeding if site conditions could affect these things.

3.1.6.2. **Shop Drawings**. Prepare and electronically submit shop drawings before fabrication for each detail of the general plans requiring the use of structural steel, forgings, wrought iron, or castings as documented in the *Guide to Electronic Shop Drawing Submittal* available on the Bridge Division website and as directed for other items the standard specifications require.

Indicate joint details on shop drawings for all welds. Provide a title block on each sheet in the lower right corner that includes:

- project identification data including federal and state project numbers,
- sheet numbering for the shop drawings,
- name of the structure or stream for bridge structures,
- name of owner or developer,
- name of the fabricator or supplier, and
- name of the Contractor.

Provide one set of 11 × 17-in. approved shop drawings in hardcopy to the Department for the inspector at the fabrication plant.

3.1.6.2.1. **Bridge Members**. Prepare drawings in accordance with AASHTO/NSBA Steel Bridge Collaboration G1.3, "Shop Detail Drawing Presentation" unless otherwise approved. Print a bill of material on each sheet, including the Charpy V-Notch (CVN) and fracture-critical requirements, if any, for each piece. Indicate fracture-critical areas of members.

3.1.6.2.2. **Non-Bridge Members**. Furnish shop drawings for non-bridge members when required by the plans or pertinent Items.

3.1.7. **Welding Procedure Specifications (WPSs)**. Submit WPSs and test reports in accordance with the applicable AWS code to the Construction Division before fabrication begins, and notify the Engineer which procedures will be used for each joint or joint type. Do not begin fabrication until the Engineer approves WPSs.

Post the approved WPSs for the welding being performed on each welding machine, or use another approved method of ensuring the welder has access to the procedure information at all times.

3.1.8. **Documentation**. Before beginning fabrication, provide a completed Material Statement Form 1818 (a.k.a. D-9-USA-1) with supporting documentation (such as mill test reports (MTRs)) that the producing mill issues and qualified personnel verifies. Ensure the documentation legibly reflects all information the applicable ASTM specifications require. Supply documents electronically to the Department.

Provide a copy of the shipping or storage invoice, as material is shipped or placed in approved storage that reflects:

- member piece mark identification and calculated weight per piece from the contract drawings,
- number of pieces shipped or in storage,
- total calculated weight for each invoice per bid item, and
- the unique identification number of the shipping or storage invoice.

The inspector's acceptance of material or finished members will not prohibit subsequent rejection if the material or members are found to be damaged or defective. Replace rejected material promptly.

3.1.9. **Material Identification**. Assembly-mark individual pieces and issue cutting instructions to the shop using a system that will maintain identity of the original piece.

Identify structural steel by standard and grade of steel. Also differentiate between material toughness requirements (CVN, fracture-critical) as well as any other special physical requirements. In addition, identify structural steel for primary members by mill identification numbers (heat numbers). Use an approved identification system. Use either paint or low-stress stencils to make identification markings on the metal. Mark the material as soon as it enters the shop and carry the markings on all pieces through final fabrication. Transfer the markings before cutting steel for primary members of bridge structures into smaller pieces. Loss of identification marking on any piece, with no other positive identification, or loss of heat number identification on any primary member piece will render the piece unacceptable for use. Unidentifiable material may be approved for use after testing to establish acceptability to the satisfaction of the Engineer. Have an approved testing facility perform testing and a licensed professional engineer sign and seal the results.

3.2. **Welding**.

3.2.1. **Details**.

3.2.1.1. **Rolled Edges**. Trim plates with rolled edges used for webs by thermal cutting.

3.2.1.2. **Weld Tabs**. Use weld tabs at least 2 in. long for manual and semi-automatic processes, at least 3 in. long for automatic processes, and in all cases at least as long as the thickness of the material being welded. Use longer weld tabs as required for satisfactory work.

3.2.1.3. **Weld Termination**. Terminate fillet welds approximately 1/4 in. from the end of the attachment except for galvanized structures and flange-to-web welds, for which the fillet weld must run the full length of the attachment, unless otherwise shown on the plans.

3.2.1.4. **No-Paint Areas at Field-Welded Connections**. Keep surfaces within 4 in. of groove welds or within 2 in. of fillet welds free from shop paint.

3.2.1.5. **Galvanized Assemblies**. Completely seal all edges of tightly contacting surfaces by welding before galvanizing.

3.2.1.6. **Submerged-Arc Welding (SAW)**. Do not use hand-held semiautomatic SAW for welding bridge members unless altered to provide automatic guidance or otherwise approved.

3.2.1.7. **Tubular Stiffeners for Bridge Members**. Weld in accordance with AWS D1.5, using WPSs qualified based on tests on ASTM A709 Gr. 50W or Gr. 50 steel for non-weathering applications and ASTM A709 Gr. 50W steel for weathering applications.

3.2.1.8. **Non-Bridge Member Weathering Steel Welds**. Provide weld metal with atmospheric corrosion resistance and coloring characteristics similar to that of the base metal for weathering steel structures fabricated per AWS D1.1.

3.2.2. **Shop Splices**.

3.2.2.1. **Shop Splice Locations**. Keep at least 6 in. between shop splices and stiffeners or cross-frames. Obtain approval for shop splices added after shop drawings are approved.

3.2.2.2. **Grinding Splice Welds**. Grind shop groove welds in flange plates smooth and flush with the base metal on all surfaces whether the joined parts are of equal or unequal thickness. Grind so the finished grinding marks run in the direction of stress, and keep the metal below the blue brittle range (below 350°F). Groove welds in web plates, except at locations of intersecting welds, need not be ground unless shown on the plans except as required to meet AWS welding code requirements.

3.2.3. **Joint Restraint**. Never restrain a joint on both sides when welding.

3.2.4. **Stiffener Installation**.

3.2.4.1. **Flange Tilt**. Members must meet combined tilt and warpage tolerances before the installation of stiffeners. Cut stiffeners to fit acceptable flange tilt and cupping. Minor jacking or hammering that does not permanently deform the material will be permitted.

3.2.4.2. **Stiffeners Near Field Splices**. Tack weld intermediate stiffeners within 12 in. of a welded field splice point in the shop. Weld the stiffeners in the field in accordance with Item 448, “Structural Field Welding,” after the splice is made.

3.2.5. **Nondestructive Testing (NDT)**. Perform magnetic particle testing (MT), radiographic testing (RT), or ultrasonic testing (UT) at the Contractor’s expense as specified in D1.5 for bridge structures. The Engineer will periodically witness, examine, verify, and interpret NDT. Additional welds may be designated for NDT on the plans. Retest repaired groove welds per the applicable AWS code after repairs are made and have cooled to ambient temperature. Complete NDT and repairs before assembly of parts into a member, but after any heat-correction of weld distortion.

3.2.5.1. **Radiographic Testing**. Radiographs must have a density of at least 2.5 and no more than 3.5, as a radiographer confirms. The density in any single radiograph showing a continuous area of constant thickness must not vary in this area by more than 0.5. Use only ASTM System Class I radiographic film as described in ASTM E1815. Use low-stress stencils to make radiograph location identification marks on the steel.

3.2.5.2. **Ultrasonic Testing**. Have UT equipment calibrated yearly by an authorized representative of the equipment manufacturer or by an approved testing laboratory.

3.2.5.3. **Magnetic Particle Testing**. Use half-wave rectified DC when using the yoke method unless otherwise approved. Welds may be further evaluated with prod method for detecting centerline cracking.

3.2.6. **Testing of Galvanized Weldments**. If problems develop during galvanizing of welded material, the Engineer may require a test of the compatibility of the combined galvanizing and welding procedures in accordance with this Section and may require modification of one or both of the galvanizing and welding procedures.

Prepare a test specimen with a minimum length of 12 in. using the same base material, with the same joint configuration, and using the welding procedure proposed for production work if testing is required. Clean and galvanize this test specimen using the same conditions and procedure that will be applied to the production galvanizing.

Examine the test specimen after galvanizing. There must be no evidence of excessive buildup of zinc coating over the weld area. Excessive zinc coating buildup will require modification of the galvanizing procedure.

Remove the zinc from the weld area of the test specimen and visually examine the surface. There must be no evidence of loss of weld metal or any deterioration of the base metal due to the galvanizing or welding procedure. Modify the galvanizing or welding procedure as required if there is evidence of deterioration or loss of weld metal, and run a satisfactory retest on the modified procedures before production work. Report procedures and results on the galvanized weldment worksheet provided by the Department.

3.3. **Bolt Holes**. Detail holes on shop drawings 1/16 in. larger in diameter than the nominal bolt size shown on the plans unless another hole size is shown on the plans.

Thoroughly clean the contact surfaces of connection parts in accordance with Item 447, “Structural Bolting,” before assembling them for hole fabrication. Make holes in primary members full-size (by reaming from a subsize hole, drilling full-size, or punching full-size where permissible) only in assembly unless otherwise approved.

Ream and drill with twist drills guided by mechanical means unless otherwise approved. If subpunching holes, punch them at least 3/16 in. smaller than the nominal bolt size. Submit the proposed procedures for approval to accomplish the work from initial drilling or punching through check assembly when numerically controlled (N/C) equipment is used. Use thermal cutting for holes only with permission of the Engineer. Permission for thermal cutting is not required for making slotted holes, when slotted holes are shown on the plans, by drilling or punching 2 holes and then thermally cutting the straight portion between them. Perform all thermal cutting in accordance with Section 441.3.5.1., “Thermal Cutting.”

Slightly conical holes that naturally result from punching operations are acceptable provided they do not exceed the tolerances of S2.1. The tolerance for anchor bolt hole diameter for bridge bearing assemblies is +1/8 in., −0.

3.4. **Dimensional Tolerances**. Meet tolerances of the applicable AWS specifications and S2.1 except as modified in this Section.

3.4.1. **Rolled Sections**. Use ASTM A6 mill tolerances for rolled sections, except D1.5 camber tolerances apply to rolled sections with a specified camber.

3.4.2. **Flange Straightness**. Ensure flanges of completed girders are free of kinks, short bends, and waviness that depart from straightness or the specified camber by more than 1/8 in. in any 10 ft. along the flange. Rolled material must meet this straightness requirement before being laid out or worked. Plates must meet this requirement before assembly into a member. Inspect the surface of the metal for evidence of fracture after straightening a bend or buckle. The Engineer may require nondestructive testing.

3.4.3. **Alignment of Deep Webs in Welded Field Connections**. For girders 48 in. deep or deeper, the webs may be slightly restrained while checking compliance with tolerances of S2.1 for lateral alignment at field-welded connections. In the unrestrained condition, webs 48 in. deep or deeper must meet the tolerances of Table 2. Girders under 48 in. deep must meet the alignment tolerances of S2.1.

Table 2
Web Alignment Tolerances for Deep Girders

Web Depth (in.)	Maximum Web Misalignment (in.)
48	1/16
60	1/8
72	1/4
84	5/16
96	5/16
108	3/8
120	7/16
132	7/16
144	1/2

3.4.4. **Bearings**. Correct bearing areas of shoes, beams, and girders using heat, external pressure, or both. Grind or mill only if the actual thickness of the member is not reduced by more than 1/16 in. below the required thickness.

3.4.4.1. **I-Beams, Plate Girders, and Tub Girders**. The plane of the bearing area of beams and girders must be perpendicular to the vertical axis of the member within 1/16 in. in any 24 in.

3.4.4.2. **Closed Box Girders**. Meet these tolerances:

- The plane of the bearing areas of the box girder is perpendicular to the vertical axis of the girder within 1/16 in. across any horizontal dimension of the bearing.
- The planes of the beam supports on the box girder are true to the vertical axis of the supported beams or girders to 1/16 in. in any 24 in.

In the shop, verify the plane of all bearing areas with the box placed on its bearings to field grade, using an approved process for verification.

3.4.4.3. **Shoes**. Meet these tolerances:

- The top bolster has the center 75% of the long dimension (transverse to the girder) true to 1/32 in., with the remainder true to 1/16 in., and is true to 1/32 in. across its entire width in the short dimension (longitudinal to the girder).
- The bottom bolster is true to 1/16 in. across its diagonals.
- For a pin and rocker type expansion shoe, the axis of rotation coincides with the central axis of the pin.
- When the shoe is completely assembled, as the top bolster travels through its full anticipated range, no point in the top bolster plane changes elevation by more than 1/16 in. and the top bolster does not change inclination by more than 1 degree, for the full possible travel.

3.4.4.4. **Beam supports**. Fabricate beam support planes true to the box girder bearing to 1/16 in. in the short direction and true to the vertical axis of the nesting girders to 1/16 in.

3.4.5. **End Connection Angles**. For floor beams and girders with end connection angles, the tolerance for the length back to back of connection angles is ±1/32 in. Do not reduce the finished thickness of the angles below that shown on the shop drawings if end connections are faced.

3.5. **Other Fabrication Processes**.

3.5.1. **Thermal Cutting**. Use a mechanical guide to obtain a true profile. Hand-cut only where approved. Hand-cutting of radii for beam copes, weld access holes, and width transitions is permitted if acceptable profile and finish are produced by grinding. Provide a surface finish on thermal-cut surfaces, including holes, in accordance with D1.5 requirements for base metal preparation. Obtain approval before using other cutting processes.

3.5.2. **Oxygen-Gouging**. Do not oxygen-gouge quenched and tempered (Q&T), normalized, or thermo-mechanically controlled processed (TMCP) steel.

3.5.3. **Annealing and Normalizing**. Complete all annealing or normalizing (as defined in ASTM A941) before finished machining, boring, and straightening. Maintain the temperature uniformly throughout the furnace during heating and cooling so the range of temperatures at all points on the member is no more than 100°F.

3.5.4. **Machining**. Machine the surfaces of expansion bearings so the travel direction of the tool is in the direction of expansion.

3.5.5. **Camber**. Complete cambering in accordance with S2.1 before any heat-curving.

3.5.6. **Heat Curving**. Heat-curve in accordance with S2.1. The methods in the AASHTO bridge construction specifications are recommended. Attach cover plates to rolled beams before heat-curving only if the total thickness of one flange and cover plate is less than 2-1/2 in. and the radius of curvature is greater than 1,000 ft. Attach cover plates for other rolled beams only after heat-curving is completed. Locate and attach connection plates, diaphragm stiffeners, and bearing stiffeners after curving, unless girder shrinkage is accounted for.

3.5.7. **Bending of Quenched and Tempered Steels**. The cold-bending radius limitations for HPS 70W in S2.1 apply to all Q&T steels.

3.6. **Nonconformance Reports (NCRs)**. Submit an NCR to the Engineer for approval when the requirements of this Item are not met. Submit NCRs in accordance with the Construction Division's NCR guidelines document. Have readily available access to the services of a licensed professional engineer experienced in steel structures design and fabrication. This licensed professional engineer may be responsible for reviewing potentially structurally deficient members in accordance with the NCR guidelines document. Receive Department approval before beginning repairs. Perform all repair work in strict compliance with the approved NCR and repair procedure.

3.7. **Shop Assembly**.

3.7.1. **General Shop Assembly**. Shop-assemble field connections of primary members of trusses, arches, continuous beam spans, bents, towers (each face), plate girders, field connections of floor beams and stringers (including for railroad structures), field-bolted diaphragms for curved plate girders and railroad underpasses, and rigid frames. Field-bolted cross-frames and rolled-section diaphragms do not require shop assembly. Complete fabrication, welding (except for shear studs), and field splice preparation before members are removed from shop assembly. Obtain approval for any deviation from this procedure. The Contractor is responsible for accurate geometry.

Use a method and details of preassembly consistent with the erection procedure shown on the erection plans and camber diagrams. The sequence of assembly may start from any location in the structure and proceed in one or both directions. An approved method of sequential geometry control is required unless the full length of the structure is assembled.

Verify by shop assembly the fit of all bolted and welded field connections between bent cap girders and plate girders or between plate girders and floor beams.

Do not measure horizontal curvature and vertical camber for final acceptance until all welding and heating operations are completed and the steel has cooled to a uniform temperature. Check horizontal curvature and vertical camber in a no-load condition.

3.7.2. **Bolted Field Connections**. Each shop assembly, including camber, alignment, accuracy of holes, and fit of milled joints, must be approved before the assembly is dismantled.

Assemble with milled ends of compression members in full bearing. Assemble non-bearing connections to the specified gap. Ream all subsize holes to the specified size while the connections are assembled, or drill

full size while the connections are assembled. Notify the Engineer before shipping if fill plates or shims are added. Adding or increasing the thickness of shims or fill plates in bearing connections requires approval. Use drift pins and snug-tight bolts during the drilling process to ensure all planes of the connection (webs and flanges) can be assembled simultaneously. Do not use tack welds to secure plates while drilling.

Secure parts not completely bolted in the shop with temporary bolts to prevent damage in shipment and handling. Never use tack welds in place of temporary bolts.

Match-mark connecting parts in field connections using low-stress stencils in accordance with the diagram in the erection drawings.

3.7.3. **Welded Field Connections**. Mill or grind bevels for groove welds. Do not cut into the web when cutting the flange bevel adjacent to the web. End preparation, backing, and tolerances for girder splices must be in accordance with Item 448, "Structural Field Welding." Details for all other field-welds must conform to the applicable AWS code unless otherwise shown on the plans.

In the shop, prepare ends of beams or girders to be field-welded taking into account their relative positions in the finished structure due to grade, camber, and curvature. Completely shop-assemble and check each splice. Match-mark the splice while it is assembled with low-stress stencils in accordance with the diagram in the erection drawings.

3.8. **Finish and Painting**.

3.8.1. **Shop Painting**. Perform shop painting of bridge members as required in DMS-8104, "Paint, Shop Application for Steel Bridge Members." Grind corners on new steel items to be painted (except for the coatings on box and tub girder interiors) that are sharp or form essentially 90° angles to an approximately 1/16 in. flat surface before blast cleaning. (A corner is the intersection of 2 plane faces.) This requirement does not apply to punched or drilled holes. Do not omit shop paint to preserve original markings.

Ensure painted faying surfaces meet the required slip and creep coefficients for bolted connections as outlined in DMS-8104, "Paint, Shop Application for Steel Bridge Members."

Use a Class A slip (minimum slip coefficient of 0.33) if no slip coefficient or corresponding surface condition is specified Perform all required testing at no expense to the Department.

Surface preparation and painting the interiors of Tub Girders and Closed Boxes is in accordance with DMS-8104, "Paint, Shop Application for Steel Bridge Members."

3.8.2. **Weathering Steel**. Provide an SSPC-SP 6 blast in the shop to all fascia surfaces of unpainted weathering steel beams. Fascia surfaces include:

- exterior sides of outermost webs and undersides of bottom flanges of plate girders and rolled beams,
- all outer surfaces of tub girders and box girders,
- all surfaces of truss members,
- webs and undersides of bottom flanges of plate diaphragms,
- bottom surfaces of floor beams, and
- any other surfaces designated as "fascia" on the plans.

Do not mark fascia surfaces. Use one of the following methods as soon as possible to remove any markings or any other foreign material that adheres to the steel during fabrication and could inhibit the formation of oxide film:

- SSPC-SP 1, "Solvent Cleaning,"
- SSPC-SP 2, "Hand Tool Cleaning,"
- SSPC-SP 3, "Power Tool Cleaning," and
- SSPC-SP 7, "Brush-off Blast Cleaning."

Do not use acids to remove stains or scales. Feather out touched-up areas over several feet.

3.8.3. **Machined Surfaces**. Clean and coat machine-finished surfaces that are in sliding contact, particularly pins and pinholes, with a non-drying, water-repellent grease-type material containing rust-inhibitive compounds. Ensure the coating material contains no ingredients that might damage the steel. Protect machined surfaces from abrasive blasting.

3.9. **Handling and Storage of Materials**. Prevent damage when storing or handling girders or other materials. Remove or repair material damaged by handling devices or improper storage by acceptable means in accordance with ASTM A6 and the applicable AWS code.

Place stored materials on skids or acceptable dunnage above the ground. Keep materials clean. Shore girders and beams to keep them upright and free of standing water. Place support skids close enough to prevent excessive deflection in long members such as columns. Do not stack completed girders or beams at the jobsite.

Protect structural steel from salt water or other corrosive environments during storage and transit.

3.10. **Marking and Shipping**. Mark all structural members in accordance with the erection drawings. If a surface is painted, make the marks over the paint. Do not use impact-applied stencils to mark painted surfaces.

Mark the weight directly on all members weighing more than 3 tons.

Keep material clean and free from injury during loading, transportation, unloading, and storage. Pack bolts of each length and diameter, and loose nuts or washers of each size, separately and ship them in boxes, crates, kegs, or barrels. Plainly mark a list and description of the contents on the outside of each package.

3.11. **Field Erection**. Do not lift and place any steel member, including girders and diaphragms, over an open highway or other open travel way unless otherwise approved. Do not allow traffic to travel under erected members until sufficiently stable as shown on approved erection drawings.

3.11.1. **Pre-Erection Conference**. Schedule and attend a pre-erection conference with the Engineer at least 7 days before commencing steel erection operations. Do not install falsework or perform any erection operations before the meeting.

3.11.2. **Methods and Equipment**. Do not tack-weld parts instead of using erection bolts. Do not tack-weld parts to hold them in place for bolting. Provide falsework, tools, machinery, and appliances, including drift pins and erection bolts. Provide enough drift pins, 1/32 in. larger than the connection bolts, to fill at least 1/4 of the bolt holes for primary connections. Use erection bolts of the same diameter as the connection bolts.

Securely tie, brace, or shore steel beams or girders immediately after erection as shown on the erection drawings. Maintain bracing or shoring until the diaphragms are in place and as specified in the erection drawings. Protect railroad, roadway, and marine traffic underneath previously erected girders or beams from falling objects associated with other construction activities.

Only welders certified or working directly under the supervision of a foreman certified in accordance with Item 448, “Structural Field Welding,” may handle torches when applying heat to permanent structural steel members.

3.11.3. **Falsework**. Construct falsework in accordance with the erection plan. Construct foundations for shore towers as shown on erection drawings. Do not use timber mats with deteriorated timbers or soil to construct shore tower foundations. Notify the Engineer of completed falsework to obtain approval before opening roadway to traffic or starting girder erection activities. Ensure falsework is protected from potential vehicle impact. Inspect and maintain falsework daily. Use screw jacks or other approved methods to control vertical adjustment of falsework to minimize the use of shims.

3.11.4. **Handling and Assembly**. Accurately assemble all parts as shown on the plans and the approved shop drawings. Verify match-marks. Handle parts carefully to prevent bending or other damage. Do not hammer if doing so damages or distorts members. Do not weld any member for transportation or erection unless noted on the plans or approved by the Engineer.

3.11.4.1. **Welded Connections**. Weld flange splices to 50% of their thickness and meet the minimum erection bracing and support requirements before releasing the erection cranes, as shown on the plans and on the approved erection plans. Field-weld in accordance with Item 448, "Structural Field Welding."

3.11.4.2. **Bolted Connections**. Before releasing the erection cranes:

- install 50% of the bolts in the top and bottom flanges and the web with all nuts finger-tight,
- meet the minimum erection bracing and support requirements shown on the plans and on the approved erection plans, and
- install top lateral bracing across the connection for tub girders, and fully tension the bolts connecting the bracing to the top flanges.

Install high-strength bolts, including erection bolts, in accordance with Item 447, "Structural Bolting." Clean bearing and faying surfaces for bolted connections in accordance with Item 447, "Structural Bolting." Clean the areas of the outside ply under washers, nuts, and bolt heads before bolt installation. Ensure the required faying surface condition is present at the time of bolting.

3.11.5. **Misfits**. Correct minor misfits. Ream no more than 10% of the holes in a plate connection (flange or web), and ensure no single hole is more than 1/8 in. larger than the nominal bolt diameter. Submit proposed correction methods for members with defects that exceed these limits or prevent the proper assembly of parts. Straighten structural members in accordance with S2.1. Make all corrections in the presence of the Engineer at no expense to the Department. Do not remove and reweld gusset plates without approval.

3.11.6. **Bearing and Anchorage Devices**. Place all bearing devices such as elastomeric pads, castings, bearing plates, or shoes on properly finished bearing areas with full and even bearing on the concrete. Place metallic bearing devices on 1/4 in.-thick preformed fabric pads manufactured in accordance with DMS-6160, "Water Stops, Nylon-Reinforced Neoprene Sheet, and Elastomeric Pads," to the dimensions shown on the plans. Provide holes in the pad that are no more than 1/4 in. larger than the bolt diameter.

Build the concrete bearing area up to the correct elevation once it has been placed below grade using mortar that meets Item 420, "Concrete Substructures," and provide adequate curing. Use only mortar for build-ups between 1/8 in. and 3/8 in. thick. Use galvanized steel shims or other approved shim materials in conjunction with mortar if the bearing area must be raised more than 3/8 in.

Provide at least 75% contact of flange to shoe with no separation greater than 1/32 in. for beams and girders. Make corrections using heat or pressure in accordance with S2.1, or with galvanized shims. Correct small irregularities by grinding.

Provide at least 85% contact between the rocker plate and the base plate. Adjust the location of slotted holes in expansion bearings for the prevailing temperature. Adjust the nuts on the anchor bolts at the expansion ends of spans to permit free movement of the span. Provide lock nuts or burr the threads.

Remove all foreign matter from sliding or machine-finished surfaces before placing them in the structure.

Restore distorted bearing pads or expansion bearings to an equivalent 70°F position after completion of all welded or bolted splices, using an approved method of relieving the load on the bearing devices.

3.11.7. **Erecting Forms**. Do not erect forms until all welding or bolting is complete and the unit is positioned and properly set on the bearings unless otherwise noted on the plans.

3.11.8. **Field Finish**. Paint in accordance with Item 446, "Field Cleaning and Painting Steel." Restore weathering steel that will remain unpainted to a uniform appearance by solvent cleaning, hand cleaning, power brush, or

blast cleaning after all welding and slab concrete placement has been completed. Remove from all unpainted weathering steel fascia surfaces (see Section 441.3.8.2., “Weathering Steel,”) any foreign material, including markings, that adheres to the steel and could inhibit formation of oxide film as soon as possible. Feather out touched-up areas over several feet. Do not use acids to remove stains or scales.

4. MEASUREMENT AND PAYMENT

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

Item 442
Metal for Structures

1. DESCRIPTION

Provide structural steel, high-strength bolts, forgings, steel castings, iron castings, wrought iron, steel pipe and tubing, aluminum castings and tubing, or other metals used in structures, except reinforcing steel and metal culvert pipe.

2. MATERIALS

Furnish mill test reports (MTRs), supplemental test documentation, and certifications required by this and other pertinent Items.

2.1. **Structural Steel**. The Engineer may sample and test steel in accordance with ASTM A370.

2.1.1. **Bridge Structures**. Provide the grade of ASTM A709 steel shown on the plans. Grade 50W, 50S, or HPS 50W may be substituted for Grade 50 at no additional cost to the Department. Use Zone 1 if no AASHTO temperature zone is shown on the plans.

2.1.2. **Non-Bridge Structures**.

2.1.2.1. **Steel Classifications**. Provide the types and grades of steel listed in this Section unless otherwise shown on the plans.

2.1.2.1.1. **Carbon Steel**. Meet ASTM A36.

2.1.2.1.2. **Low-Alloy Steel**. Meet the requirements of one of the following standards:

- ASTM A529 Grade 50;
- ASTM A572 Grade 50 or 55;
- ASTM A588;
- ASTM A709 Grade 50, 50S, 50W, or HPS 50W; or
- ASTM A992.

Specify ASTM A6 supplemental requirement S18, “Maximum Tensile Strength,” for material used for sign, signal, and luminaire supports.

2.1.2.2. **Impact Testing**. Tension members and components of the following structure types, if more than 1/2 in. thick. Other members designated on the plans must meet the Charpy V-notch (CVN) requirements of Table 1:

- base plates for roadway illumination assemblies, traffic signal pole assemblies, high mast illumination poles, camera poles, and overhead sign supports;
- pole mounting plates, arm mounting plates, and clamp-on plates for traffic signal pole assemblies;
- arm stiffeners, pole gussets, and stiffeners for traffic signal pole long mast arm assemblies (50 ft. to 65 ft.);
- pole shafts, ground sleeves, and handhole frames for high mast illumination poles;
- W-columns, tower pipes, multiple-sided shafts, tower pipe and multiple-sided shaft connection plates, chord angles, chord splice plates or angles, and truss bearing angles for truss type overhead sign supports; and

- pipe posts, pipe arms, post and arm flange plates, and handhole frames for monotube overhead sign supports.

Table 1
CVN Requirements for Non-Bridge Steel

Material	Thickness	Minimum CVN Toughness
ASTM A36, A53, A242, A500, A501, A709 Gr. 36, any other steel with minimum specified yield point below 40 ksi	up to 4"	15 ft.-lb. at 70°F
ASTM A572,[1] A588,[1] A633,[1] any other steel with minimum specified yield point between 40 and 65 ksi, inclusive	up to 2"	15 ft.-lb. at 70°F
	over 2" to 4", mechanically fastened	15 ft.-lb. at 70°F
	over 2" to 4", welded	20 ft.-lb. at 70°F
Any steel with minimum specified yield point over 65 ksi and under 90 ksi[2]	up to 2-1/2"	20 ft.-lb. at 50°F
	over 2-1/2" to 4", mechanically fastened	20 ft.-lb. at 50°F
	over 2-1/2" to 4", welded	25 ft.-lb. at 50°F

1. Reduce the testing temperature by 15°F for each 10-ksi increment or fraction thereof above 65 ksi if the yield point of the material given on the MTR exceeds 65 ksi.
2. Reduce the testing temperature by 15°F for each 10-ksi increment or fraction thereof above 85 ksi if the yield point of the material given on the MTR exceeds 85 ksi.

Use the (H) frequency of testing for material with minimum specified yield point up to 50 ksi. Use the (P) frequency of testing for material with minimum specified yield point over 50 ksi. Ensure steel is sampled and tested in accordance with ASTM A673.

2.1.3. **Other Components**.

2.1.3.1. **Miscellaneous Bridge Components**. Provide steel that meets ASTM A36, A709 Grade 36, or A500 Grade B for members such as steel bearing components not bid under other Items, steel diaphragms for use with concrete bridges, and armor and finger joints, unless otherwise shown on the plans.

2.1.3.2. **Shear Connectors and Anchors**. Provide cold-drawn bars for stud shear connectors, slab anchors, and anchors on armor and finger joints that meet the requirements of ASTM A108, Grade 1010, 1015, 1018, or 1020, either semi-killed or killed, and have the tensile properties given in Table 2 after drawing or finishing. Determine tensile properties in accordance with ASTM A370.

Table 2
Minimum Tensile Properties for Bar Stock

Tensile strength	60 ksi
Yield strength	50 ksi
Elongation	20% (2")
Reduction of area	50%

Provide certification from the manufacturer that the studs or anchors as delivered have the required material properties.

2.1.3.3. **Fasteners**. Provide high-strength bolts that meet ASTM A325 or A490 as shown on the plans. The Department may sample high-strength bolts, nuts, and washers for structural connections in accordance with Tex-719-I.

Follow the requirements of Item 447, "Structural Bolting," for tests, test reports, and supplemental requirements for high-strength bolts, nuts, and washers.

Use bolts that meet ASTM A307 and nuts that meet ASTM A563 when ASTM A325 or A490 bolts are not shown on the plans.

2.1.3.4. **Slip-Resistant Deck Plates**. Furnish steel for deck plates that meets ASTM A786 and one of A242, A588, or A709 Gr. 50W. State the type and trade name of material to be used on the shop drawings.

2.1.3.5. **Rail Posts**. Provide material for rail posts that meets ASTM A36 or ASTM A709 Grade 36 unless otherwise shown on the plans.

2.2. **Steel Forgings**. Provide steel forgings for pins, rollers, trunnions, or other forged parts that meet ASTM A668, Class C, D, F, or G, as shown on the plans. For pins 4 in. or smaller in diameter for non-railroad structures, material that meets ASTM A108, Grades 1016 to 1030, with a minimum yield strength of 36 ksi, may be used instead.

2.3. **Steel Castings**. Provide steel castings that meet ASTM A27, Grade 70-36.

2.4. **Iron Castings**. Provide iron castings that are true to pattern in form and dimensions; free from pouring faults, sponginess, cracks, blow holes, and other defects in positions affecting their strength and value for the service intended; and meet the standards shown in Table 3.

Table 3
Standards for Iron Castings

Casting Material	ASTM Standard	Grade or Class
Gray iron	A48	35B
Malleable iron	A47	32510
Ductile iron	A536	70-50-05

2.5. **Steel Tubing**. Provide steel tubing that meets ASTM A500, Grade B unless otherwise shown on the plans. Tubing that meets API Standard 5L, Grade X52 may be used if produced by a mill listed in the standard API specifications as authorized to produce pipe with the API monogram. Hydrostatic tests are not required for API 5L steel, and instead of an MTR, the manufacturer may furnish a certificate for each lot or shipment certifying the tubing meets the requirements of this Section.

2.6. **Pipe Rail**. "Pipe" includes special extruded and bent shapes. Provide pipe that is rolled, extruded, or cold-pressed from a round pipe or flat plate, and of the section shown on the plans.

Ensure the design of the cold press and dies results in a pipe of uniform section-free from die marks. Cut the pipe to the lengths required once it has been formed to the required section. Make the end cuts and notches at the angles to the axis of the pipe required to produce vertical end faces and plumb posts when required by the plans. Provide a neat and workmanlike finish when cutting and notching pipe.

2.7. **Aluminum**. Provide aluminum materials that meet the standards shown in Table 4 unless otherwise shown on the plans.

Table 4
Aluminum Standards

Material	ASTM Standard	Alloy-Temper
Castings	B108	A444.0-T4
Extrusions	B221	6061-T6
Sheet or plate	B209	6061-T6

When testing is required, cut test specimens from castings from the lower 14 in. of the tension flange, but not at the junction of the rib or base. Flatten the curved surfaces before machining. Provide standard test specimens in conformance with ASTM E8.

3. CONSTRUCTION

3.1. **Fabrication, Erection, and Painting**. Fabricate, weld, and erect structural metal in accordance with Item 441, "Steel Structures," Item 447, "Structural Bolting," Item 448, "Structural Field Welding," and the applicable AWS welding code. Paint in accordance with Item 446, "Field Cleaning and Painting Steel." Aluminum or galvanized steel members do not require painting unless otherwise shown on the plans.

3.2. **Galvanizing**. Galvanize fabricated steel items, steel castings, bolts, nuts, screws, washers, and other miscellaneous hardware in accordance with Item 445, "Galvanizing." Galvanizing is not required unless specified.

4. MEASUREMENT

This Item will be measured by the pound of structural metal furnished and placed in a complete structure not including the weight of erection bolts, paint, or weld metal.

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

The maximum percent variance from the plans quantity will be as given in Table 5.

Table 5
Percent Variance

Quantity	Variance
Over 1,000,000 lb.	1/2%
100,000 through 1,000,000 lb.	1%
Under 100,000 lb.	1-1/2%

If the requests for increases in sizes or weights of members are approved, measurement will be made on the sizes or weights shown on the plans.

Castings, bearing plates, anchor bolts, drains, deck plates, armor and finger joints, and other metal for which no separate measurement is specified will be included in the total quantity of structural steel.

The weights of rolled materials (such as structural shapes and plate) will be computed on the basis of nominal weights and dimensions using measurements shown on the plans. Deductions will not be made for material that is removed for copes, clips, planing, or weld preparation. The weight of castings will be computed from the dimensions shown on the approved shop drawings. Shoes will be measured by the weights shown on the plans.

Weight of high-strength fasteners will be based on Table 6. Weight of other metal will be based on Table 7.

Splices will be measured as follows:

- No additional weight will be allowed for weld metal in a welded splice.
- Where a bolted splice is permitted as an alternate for a welded splice, measurement will be made on the basis of a welded splice.
- Where a bolted splice is required, the weight of the splice material, bolt heads, washers, and nuts will be measured with no deduction for holes.

Table 6
Pay Weight for High-Strength Fasteners, Pounds per Hundred Units

Diameter	Item		
	Bolt heads	Nuts	Washers
3/4"	15	19	4.8
7/8"	23	30	7.0
1"	32	43	9.4
1-1/8"	45	59	11
1-1/4"	64	79	14

Table 7
Pay Weight for Metals

Material	Weight (lb./cu. in.)
Steel	0.2836
Cast iron	0.2604
Wrought iron	0.2777

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under "Measurement" will be paid for at the unit price bid for "Structural Steel" of the type (Rolled Beam, Plate Girder, Tub Girder, Box Girder, Railroad Through-Girder, Railroad Deck-Girder, Miscellaneous Bridge, Miscellaneous Non-Bridge) specified. This price is full compensation for materials, fabrication, transportation, erection, paint, painting, galvanizing, equipment, tools, labor, and incidentals.

Item 447
Structural Bolting

1. DESCRIPTION

Furnish and install high-strength bolts for structural connections.

2. MATERIALS

2.1. **General**. Use the same supplier for bolts and nuts to ensure proper fit. Have the manufacturer or distributor perform rotational-capacity (R-C) tests in accordance with Tex-452-A on all bolt, nut, and washer assemblies. Test each combination of bolt production lot, nut lot, and washer lot as an assembly and assign an R-C lot number to each lot tested. Test two samples from each assigned R-C lot.

Furnish a manufacturer's certified test report (MCTR) or a distributor's certified test report (DCTR) for each R-C lot supplied. Include in the MCTR or DCTR:

- results of the R-C tests,
- R-C lot number,
- manufacturing location for assembly components,
- date and location of tests, and
- a statement that the materials represented by the test report are in accordance with the specifications.

2.2. **Bolt Assemblies**. Provide ASTM F3125 bolts, nuts, and washers meeting the type, grade, and finish requirements shown in Table 1, unless otherwise shown on the plans.

Use Grade A325 or Grade A490 Type 3 plain (uncoated) bolts for weathering steel as specified and Grade A325 Type 1 galvanized bolts for coated steel, unless otherwise shown on the plans.

Provide bolts long enough for the installed bolt end to be flush with or outside the face of the nut.

Ensure galvanized nuts are lubricated with a lubricant containing a dye of a color that contrasts with the color of the galvanizing. Order ASTM A563 nuts with supplemental requirement S2 if they will be galvanized.

Table 1
ASTM Type, Finish, and Grade for Structural Bolts, Nuts, and Washers

	ASTM Designation	Bolt Type	Bolt Finish	ASTM A563 Nut Grade and Finish	ASTM F436 Washer Type and Finish
Heavy-hex holts[1]	A325	1	Galvanized	DH[2], galvanized and lubricated	1; galvanized
	A325	3	Plain	C3 and DH3; plain and lubricated	3; plain
	A490	3	Plain	DH3; plain and lubricated	3; plain
Tension-control colts[1]	F1852	1	Galvanized	DH,[2] galvanized and lubricated	1; galvanized
	F1852	3	Plain	C3 and DH3; plain and lubricated	3; plain
	F2280	3	Plain	DH3; plain and lubricated	3; plain

1. ASTM F3125 high strength structural bolts
2. ASTM A194 heavy hex Grade 2H nuts may be substituted.

2.3. **Washer-Type Indicating Devices**. Use compressible-washer type direct-tension indicators that meet ASTM F959 if allowed. Alternative washer-type indicating devices must be approved. Provide detailed testing, installation, and inspection requirements prepared by the manufacturer.

2.4. **Storage**. Protect all bolts and nuts from dirt and moisture at the jobsite. Remove from protected storage only those bolts and nuts anticipated to be installed during a workday. Return unused fasteners to protected storage at the end of the day. Do not clean fasteners of lubricant present in the as-delivered condition. Perform a field R-C test at the Contractor's expense in accordance with Tex-452-A on any lot of fasteners that shows signs of rust, dirt, or loss of lubrication as directed. Apply additional lubrication and rerun the R-C test before installing bolts if the fasteners fail the R-C test. Replace any fasteners that cannot be re-lubricated to pass the field R-C test. Tension control bolts may be re-lubricated only by the manufacturer.

2.5. **Sampling and Testing**. Sample high-strength bolts, nuts, and washers in accordance with Tex-719-I, when directed. Perform field R-C tests as directed in accordance with Tex-452-A. Perform installation verification tests in accordance with Section 447.4.1., "Verification Testing."

2.6. **Fitup Bolts and Erection Pins**. Provide heavy-hex fitup bolts of the same diameter as the connection bolts. Do not use washer-type indicating devices for fitups. Do not reuse galvanized bolts or Grade A490 bolts that have been used as fitup bolts. Provide enough erection or drift pins, 1/32 in. larger than the bolt diameter.

2.7. **Paint Markers**. Provide white or yellow paint markers for marking bolts or nuts for wrench calibration, R-C tests, and bolt installation.

3. EQUIPMENT

3.1. **Testing Equipment**. Provide a calibrated tension-measuring device (Skidmore-Wilhelm or equivalent), calibrated torque wrench, and other accessories necessary to perform the installation verification test and the R-C test, and to calibrate hydraulic or electric torque wrenches.

3.2. **Wrenches**. Furnish either of the following types of wrenches.

3.2.1. **Air-Driven Impact Wrenches**. Furnish air-driven impact wrenches, air compressors, and related accessories of enough capacity to properly tension high-strength bolts. Impact wrenches should be of enough size and capacity to be able to tension fully a bolt in less than 15 sec. Repair or replace any wrenches that are unable to apply full tension to a bolt within this time.

3.2.2. **Calibrated Torque Wrenches**. Furnish calibrated hydraulic or electric torque wrench and related accessories capable of properly tensioning high-strength bolts. Calibrate the wrench to stall out or cut out completely when the bolt tension reaches 1.05 times the tension shown in Table 2. Calibrate the wrench by tensioning three bolts of each size in a calibrated tension-measuring device (Skidmore-Wilhelm or equivalent). Mark each bolt and verify the rotation from snug-tight when calibrating the wrench in accordance with Section 447.4.5.3.1., "Turn-of-the-Nut Method." Calibrate the wrench at least once each working day or as directed. Recalibrate the wrench for changes in bolt diameter; changes in bolt length greater than two bolt diameters; significant differences in the surface condition of the bolts, threads, nuts, or washers; or changes in the equipment or hose length.

4. CONSTRUCTION

4.1. **Verification Testing**. Have each member of the bolting crew that will perform the actual work complete an acceptable pre-installation verification test in the presence of the Engineer. Only crewmembers that have demonstrated proper workmanship by verification testing may perform production bolting work.

4.1.1. **Air-Driven Impact Wrench**. Perform an installation verification test on three complete fastener assemblies of each combination of diameter, length, grade, and lot to be installed before beginning bolting. Follow the bolt-tensioning procedures in accordance with Section 447.4.5.3., "Tension Bolts." Use a calibrated tension-measuring device (Skidmore-Wilhelm or equivalent) to verify and demonstrate that the method for

estimating the snug-tight condition and controlling the turns from snug-tight develops a tension greater than 1.05 times the tension shown in Table 2. The snug-tight condition is defined as the tightness that exists when the plies of the joint are in firm contact.

4.1.2. **Calibrated Torque Wrench**. Calibrate the wrench before beginning bolting in accordance with Section 447.3.2.2., "Calibrated Torque Wrenches." Use the bolting crew that will perform the actual work for the calibration and calibrate the wrench in the presence of the Engineer. Follow the bolt-tensioning procedures in accordance with Section 447.4.5.3., "Tension Bolts."

4.1.3. **Direct-Tension Indicator**. Use a calibrated tension-measuring device for compression-type indicators to verify the gap is not less than 0.015 in. or the job inspection gap specified by the manufacturer when tension in the bolt reaches 1.05 times the tension shown in Table 2.

Follow the manufacturer's instructions for pre-installation verification testing methods and frequency for alternative washer type indicating devices deemed acceptable.

4.2. **Workmanship**. The Engineer will disqualify any crewmembers not adhering to proper installation methods during production work. Disqualified crew may not perform further bolting work until they complete an additional pre-installation verification test suitable to the Engineer.

4.3. **General**. Ensure all material within the grip of the bolt is steel. Do not allow any compressible material such as gaskets or insulation within the grip. Ensure the slope of parts in contact with the bolt head or nut does not exceed 1:20 with respect to a plane normal to the bolt axis. Prepare all joint surfaces, including those in contact with the bolt heads, nuts, or washers, so that the surfaces are free of dirt, loose rust, loose mill scale, burrs, and other matter that would prevent solid seating of the parts.

Replace any bolts and nuts installed for shipping purposes unless the shop drawings specify the shop-installed bolts are to be fully tensioned in the shop. Do not tension bolts that have been installed snug-tight in the shop. Remove any bolts installed snug-tight in the shop and replace them with new bolts. Inspect and prepare the joint surfaces after removing shop-installed bolts that are not fully tensioned in the shop.

Provide a hardened washer for heavy-hex and tension-control bolts under either the nut or the bolt head, whichever is turned during tensioning. Install hardened washers under both the nut and bolt head of Grade A490 bolts when the outer plies being fastened have a yield strength less than 40 ksi.

Install an ASTM F436 washer for direct-tension indicators as follows:

- under the nut when the nut is turned and the direct-tension indicator is located under the bolt head,
- between the nut and the direct-tension indicator when the nut is turned and the direct-tension indicator is located under the nut,
- under the bolt head when the bolt head is turned and the direct-tension indicator is located under the nut, and
- between the bolt head and the direct-tension indicator when the bolt head is turned and the direct-tension indicator is located under the bolt head.

Tension all bolts to provide the minimum bolt tension values shown in Table 2.

Erect steel in accordance with Item 441, "Steel Structures." Do not tack-weld any parts to eliminate fitup bolts or to hold parts together while bolting.

Remove lubricant from bolt assemblies on painted structures after tensioning and before coating the connections.

Re-tighten the nuts or tack weld the nuts to the bolts when bolts are used to temporarily support welded diaphragms after completing the welding operations if the diaphragms are over vehicular or pedestrian traffic.

Table 2
Bolt Tension

Nominal Bolt Size, in.	Minimum Tension (kips)	
	Grade A325 Bolts	Grade A490 Bolts
1/2	12	15
5/8	19	24
3/4	28	35
7/8	39	49
1	51	64
1-1/8	64	80
1-1/4	81	102
1-3/8	97	121
1-1/2	118	148

4.4. **Preparation of Faying Surfaces**. Perform blast cleaning or painting of faying surfaces in accordance with Item 441. Provide an AMPP-SP 10 blast cleaning before shipment for weathering steel. Do not wire-brush weathering steel faying surfaces.

4.5. **Bolt Installation**. Use the following procedure for bolt installation of a complete connection.

4.5.1. **Fair-Up Holes**. Use a minimum number of erection or drift pins, as directed, in the holes to “fair-up” all holes.

4.5.2. **Install Bolts**. Install bolts in all remaining holes of the connection. Do not use excessive force, which could result in damage to the threads, to install the bolts. Increase the number of erection or drift pins as necessary to align the holes if force is required to install the bolts. Do not ream the holes unless approved. Ream the holes in accordance with Section 441.3.11.5., “Misfits,” if approved. Remove the erection or drift pins and install bolts in these holes. Bring the connection to a full snug-tight condition by snugging systematically from the most rigid part of the connection to the free edges. The snug-tight condition is defined as the tightness that exists when the plies of the joint are in firm, full contact and all of the bolts in the joint have been tightened enough to prevent the removal of the nuts without the use of a wrench. A snug-tight condition can usually be attained by a few impacts of an impact wrench or the full effort of a worker using an ordinary spud wrench, as demonstrated in the installation verification test. As necessary, re-snug previously snugged bolts that may have relaxed due to the subsequent snugging of adjacent bolts to ensure all bolts are simultaneously snug-tight and the connection plates are in full contact.

Fully tighten a minimum number of bolts as directed until the plies are in full contact if snugging does not bring the plies of the joint into full contact. Mark these bolts as fitup bolts. Use a non-galvanized Grade A325 bolt of the same diameter as a fitup bolt in connections requiring the use of galvanized Grade A325 bolts. Re-snug all remaining bolts.

Do not use washer-type indicating devices to bring the connection to a snug-tight condition. Rather, install heavy-hex bolt assemblies in enough holes (approximately 20%) to attain firm, full contact between plies. Remove the heavy-hex bolts and install the washer-type indicating device assemblies after firm contact is established by connections in surrounding bolt holes.

4.5.3. **Tension Bolts**. Loosen all fitup bolts after tensioning all the other bolts in the connection. Ungalvanized Grade A325 bolts used as fitup bolts may be reused in a connection using this type of bolt. Replace all galvanized bolts and Grade A490 bolts used as fitup bolts. Tension these remaining untensioned bolts in accordance with this Section. Ensure the element not turned by the wrench (bolt head or nut) does not rotate.

4.5.3.1. **Turn-of-the-Nut Method**. Match-mark the nuts and the protruding bolt ends after the bolts have been brought up to snug-tight condition and before final tensioning so that actual rotation can be determined. Tension all bolts in the connection to their final tension by the amount of rotation shown in Table 3. Start final tensioning at the center or most rigid part of the connection and progress toward the free edges.

4.5.3.2. **Calibrated Wrench Method**. Use a calibrated hydraulic torque wrench to tension all bolts to 1.05 times the tension shown in Table 2 after they have been brought to the snug-tight condition. Calibrate the wrench in accordance with Section 447.3.2.2., "Calibrated Torque Wrenches." Start tensioning at the most rigid part of the connection and proceed to the free edges. Return the wrench to re-tension previously tensioned bolts that may have relaxed due to the subsequent tensioning of adjacent bolts. Place marks on the socket at one-third points so the amount of rotation can be visually determined.

4.5.3.3. **Washer-Type Indicating Devices**.

4.5.3.3.1. **Compressible-Washer Type, Direct-Tension Indicators**. Ensure the direct-tension indicator arches are oriented away from the work and that they bear against the hardened bearing surface. Confirm the appropriate feeler gauge is accepted in at least half the spaces between protrusions before tensioning and refused entry in at least half the spaces between protrusions after tensioning.

4.5.3.3.2. **Alternative Washer Type Indicating Devices**. Follow the procedures prepared by the manufacturer and approved. Verify proper installation after tensioning.

4.5.4. **Bolt Reuse**. Do not reuse Grade A490 or galvanized Grade A325 bolts. Ungalvanized Grade A325 bolts may be reused once if the threads have not been damaged. Re-tensioning previously tensioned bolts loosened by the tensioning of adjacent bolts is not considered to be reuse.

Tension all bolts in a connection within 10 days of installation. Bolts not tensioned within 10 days of installation are subject to field R-C testing. Re-lubricate or replace any installed bolts that do not have enough lubrication as determined by the field R-C test.

Table 3
Nut Rotation from Snug-Tight Condition[1]

Bolt Length (underside of head to end of bolt)	Disposition of Outer Face of Bolted Parts		
	Both Faces Normal to Bolt Axis	One Face Normal to Bolt Axis and Other Face Sloped Less than 1:20 (beveled washer not used)	Both Faces Sloped Less than 1:20 from Bolt Axis (beveled washer not used)
Up to and including 4 bolt diameters	1/3 turn	1/2 turn	2/3 turn
Over 4 bolt diameters up to and including 8 diameters	1/2 turn	2/3 turn	5/6 turn
Over 8 bolt diameters up to and including 12 diameters[2]	2/3 turn	5/6 turn	1 turn

1. Nut rotation is relative regardless of the element (nut or bolt) being turned. The tolerance is –0°, +30° for bolts installed by 1/2 turn or less and –0°, +45° for bolts installed by 2/3 turn or more.
2. Determine the required rotation for bolt lengths greater than 12 diameters using the installation verification test in a simulated connection of solidly fitted steel.

5. MEASUREMENT AND PAYMENT

Installation and testing of bolts will not be paid for directly, but will be subsidiary to pertinent Items requiring the use of high-strength bolts.

When payment for the structure associated with the bolts is made under Item 442, "Metal for Structures," bolts, nuts, and washers will be paid for in accordance with Item 442.

Item 448
Structural Field Welding

1. DESCRIPTION

Field-weld metal members using the shielded metal arc or flux cored arc welding processes.

2. MATERIALS

Provide electrodes for shielded metal arc welding (SMAW) conforming to the requirements of the latest edition of ANSI/AWS A5.1 or ANSI/AWS A5.5.

Provide electrodes for flux cored arc welding (FCAW) conforming to the requirements of the latest edition of ANSI/AWS A5.20 or ANSI/AWS A5.29.

Provide electrodes and flux-electrode combinations named on the Department's MPL. To request that a product be added to this list or to renew an expired approval, the Contractor or the consumable manufacturer must submit certified reports of all tests required by the applicable AWS A5 specification according to the applicable welding code to the Construction Division. For most structural steel construction, the applicable welding code is AASHTO/AWS D1.5 or ANSI/AWS D1.1. For reinforcing steel, the applicable code is ANSI/AWS D1.4. Tests must be conducted on electrodes of the same class, size, and brand and manufactured by the same process and with the same materials as the electrodes to be furnished. Resubmit electrodes or flux-electrode combinations every 12 months for renewal.

Table 1 shows the classes of electrodes required. Use electrodes with the type of current, with the polarity, and in the positions permitted by AWS A5.1 and A5.5 for SMAW. AWS A5.20 and A5.29 specifications govern for FCAW. Obtain approval for electrode use on steel not listed in Table 1.

Table 1
Classification of Electrodes Permitted

Type of Steel (ASTM Standards)	Electrode Specification	Process	Filler Metal Requirements
Steel piling Armor joints A500 A501	AWS A5.1 or A5.5	SMAW	E60XX E70XX or E70XX-X
	AWS A5.20 or A5.29	FCAW	E6XTX-X E7XTX-X (except -2, -3, -10, -GS)
A36 A572 Gr. 50 A588 A242 A709 Gr. 36. 50, or 50S	AWS A5.1 or A5.5	SMAW	E7016 E7018 E7028
	AWS A5.20 or A5.29	FCAW	E7XT-1 E7XT-5 E7XT-6 E7XT-8
Weathering steel A588 A242 A709 Gr. 50W	AWS A5.5	SMAW	E8018-W E8016-C3 E8018-C3 E8016-C1 E8018-C1 E8016-C2 E8018-C2
	AWS 5.29	FCAW	E8XT1-W E8XTX-Ni1 E8XTX-Ni2 E8XTX-Ni3
A709 Gr. HPS 70W	AWS A5.5	SMAW	E9018-M-H8R
Reinforcing steel Grade 40	AWS A5.1 or A5.5	SMAW	E70XX
Reinforcing steel Grade 60	AWS A5.5	SMAW	E90XX
Permanent metal deck forms	AWS A5.1 or A5.5	SMAW	E6010 E6011 E6013 E7018

Note—Low-hydrogen electrodes applicable to the lower strength base metal may be used in joints involving base metals of different yield points or strengths.

E7010 and E8010 electrodes may be used when welding the root passes of beam and girder splices if the requirements of Section 448.4.3.5.1., “High-Cellulose Electrodes for Root Passes,” are met.

Use electrodes meeting the diffusible hydrogen requirements for fracture-critical welding in AASHTO/AWS D1.5 when welding fracture-critical applications.

Use gas or gas mixtures that are welding grade and have a dew point of −40°F or lower for gas-shielded FCAW. Furnish certification to the Engineer that the gas or gas mixture is suitable for the intended application and will meet the dew point requirements.

3. EQUIPMENT

Provide electrode drying and storing ovens that can maintain the required temperatures specified in Section 448.4.3.1., “Electrode Condition.” Each oven must have a door that is sealed and can be latched. Each oven must have a small port that may be opened briefly to insert a thermometer or the oven must be equipped with a thermometer that allows for direct reading of temperature inside the oven without opening the oven. Provide equipment able to preheat and maintain the temperature of the base metal as required and as shown on the plans. Provide approved equipment (e.g., temperature indicator sticks or infrared thermometer) for checking preheat and interpass temperatures at all times while welding is in progress.

Provide welding equipment meeting the requirements of the approved welding procedure specifications (WPS), if required, and capable of making consistent high-quality welds.

4. CONSTRUCTION

4.1. **Procedure Qualification**. Use the proper classification and size of electrode, arc length, voltage, and amperage for the thickness of the material, type of groove, welding positions, and other circumstances of the work.

Submit WPSs for FCAW, qualified in accordance with AASHTO/AWS D1.5 for approval before any field welding on a project.

4.2. **Welder Qualification**. Provide Department certification papers for each welder and for each welding process to be used before welding, except for miscellaneous welds described in Section 448.4.2.1.1., "Miscellaneous Welding Applications." Certification is issued by the Department as described in Section 448.4.2.2., "Certified Steel Structures Welder."

4.2.1. **Miscellaneous Welding**. A qualified welder is an experienced welder who is capable of making welds of sound quality but does not have Department certification papers. The Engineer will check the welder's ability by conducting a jobsite test in accordance with Section 448.4.2.1.2., "Miscellaneous Weld Qualification Test," before welding begins. Furnish all materials and equipment necessary for this test.

4.2.1.1. **Miscellaneous Welding Applications**. A welder certified for structural or reinforcing steel or a qualified welder may make miscellaneous welds of the following types:

- splicing reinforcing steel to extend bars in the bottom of a drilled shaft;
- attaching chairs to the reinforcing steel cage of a drilled shaft;
- armor joints and their supports;
- screed rail and form hanger supports where permitted on steel units;
- reinforcing steel to R-bars for lateral stability between prestressed beams, spirals, or bands to reinforcing bars in drilled shaft cages;
- permanent metal deck forms;
- additional steel added in railing when slip-form construction is used; and
- other similar miscellaneous members that have no load-carrying capacity in the completed structure.

4.2.1.2. **Miscellaneous Weld Qualification Test**. A qualified welder must pass a jobsite Miscellaneous Weld Qualification Test before welding:

- Make a single-pass fillet weld of 1/4 in. maximum size in the vertical position approximately 2 in. long on 1/2-in. plate in the location shown in Figure 1. Use the same electrode proposed for the work.
- The Engineer will visually inspect the fillet weld for a reasonably uniform appearance and then rupture the weld as shown in Figure 2 with a force or by striking it with a hammer.
- The fractured surface of the weld will be inspected to ensure complete penetration into the root of the joint, complete fusion to the base metal, and no inclusion or porosity larger than 3/32 in. in its greatest dimension.

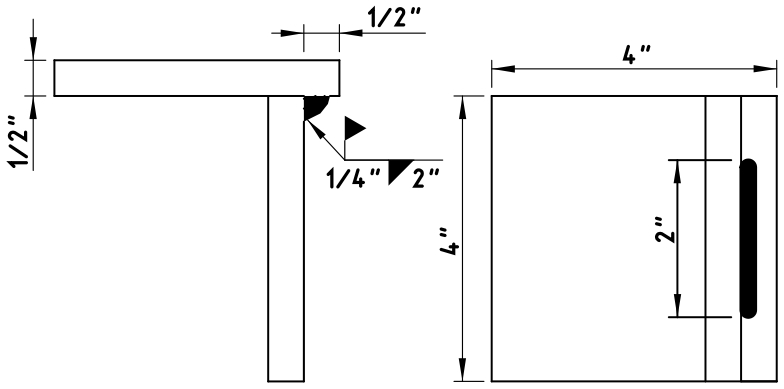


Figure 1
Miscellaneous Qualification—Fillet Weld Break Specimen

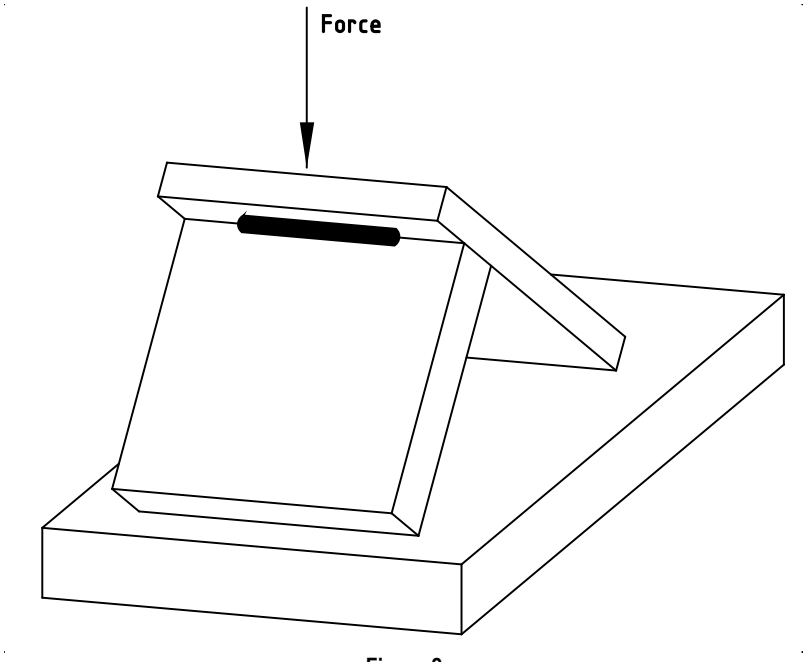


Figure 2
Miscellaneous Qualification—Method of Rupturing Specimen

A welder who fails the Miscellaneous Weld Qualification Test may take a retest under the following conditions:

- The retest occurs immediately and consists of 2 test welds as described above with both test specimens meeting all of the requirements.
- The retest occurs after 30 days if the welder provides evidence of further training or practice. In this case the test consists of a single test weld.

Qualification by the Miscellaneous Weld Qualification Test is effective immediately upon satisfactory completion of the test and remains in effect for the duration of a project.

4.2.2. **Certified Steel Structures Welder**. Before making non-miscellaneous welds on structural steel, a welder must pass the AASHTO/AWS D1.5 qualification test for groove welds for plates of unlimited thickness in the vertical (3G) and overhead (4G) positions with the following additional requirements:

- Use metal for test plates that meets Item 442, "Metal for Structures," with a minimum yield point of 36 ksi. The minimum width of test plate must be sufficient to accommodate the radiograph inspection of 5-1/4 continuous inches of the weld, not counting the ends of the weld.
- Use approved electrodes meeting the required class in accordance with Table 1 and, in the case of FCAW, in accordance with the approved WPS.
- Have a radiographic inspection performed on the weld on each test plate. Any porosity or fusion-type discontinuity with greatest dimension larger than 1/16 in. found in the weld will result in failure of the test. Discontinuities with greatest dimension less than 1/16 in. are acceptable provided the sum of their greatest dimensions does not exceed 3/8 in. in any inch of weld.
- Have 2 side-bend specimens prepared, tested, and inspected for each test plate.

The test must be administered by an approved laboratory and welding observed by laboratory personnel. Submit 2 copies of the certification issued by the laboratory, all accompanying test papers, and the radiographic films to the Bridge Division for review. The Bridge Division issues Department certification papers if the laboratory's certification is approved. A welder must also demonstrate to the Engineer a thorough knowledge of the required welding procedures together with the ability and desire to follow them and make welds of sound quality and good appearance. The certification issued by an approved laboratory is accepted for 1 mo. from the time of certification, during which time the welder may work on Department projects if the work is satisfactory. Certification papers issued by the Department remain in effect as long as the welder performs acceptable work as determined by the Bridge Division. The certification may be cancelled at any time if the welder's work is not acceptable.

For SMAW, a welder certified using EXX18 electrodes is qualified to weld with all approved SMAW electrodes up to E90XX to join metals with a maximum specified yield strength of 65 ksi.

4.3. **Welding Steel Structures**.

4.3.1. **Electrode Condition**.

4.3.1.1. **SMAW**. For electrodes with low-hydrogen coverings in conformance with AWS A5.1, dry to the manufacturer's written drying instructions or dry for at least 2 hours between 450°F and 500°F. For electrodes with low-hydrogen coverings conforming to AWS A5.5, dry for at least 1 hour between 700°F and 800°F or as specified by the electrode manufacturer. If using electrodes from a newly opened undamaged hermetically sealed container, drying is not required. Store electrodes in ovens held at a temperature of at least 250°F immediately after drying or removal from hermetically sealed container. Elapsed time permitted between removal of an electrode from the storage oven or hermetically sealed container and use of the electrode is given in Table 2. If the electrodes have the moisture resistance designator "R" and are being used on steel with minimum specified yield strength of 50 ksi or less, exposure time may be increased up to 9 hr.

Table 2
SMAW Electrode Exposure Limits

Electrode Type	Exposure Time (hr.)
E70	4
E80	2
E90	1

Leave electrodes in the holding oven for at least 4 hr. at 250°F before reusing if they are placed back in it before the times given in Table 2 have lapsed. The Engineer may reduce times allowed for use without re-drying in humid atmospheres. Do not redry electrodes more than once. Do not use electrodes with flux that has been wet, cracked, or otherwise damaged.

4.3.1.2. **FCAW**. Protect or store welding wire coils removed from the original package to keep their characteristics or welding properties intact. Do not use coils or portions of coils that are rusty.

4.3.1.3. **Special Applications**. Dry electrodes for fracture-critical applications or when welding steel not shown in Table 1 in accordance with the manufacturer's specifications and AASHTO/AWS D1.5.

4.3.2. **Environmental Conditions**. Do not weld when the air temperature is lower than 20°F; when surfaces are wet or exposed to rain, snow, or wind; or when operators are exposed to inclement conditions. Provide wind breaks to protect welding operations from winds greater than 5 mph.

4.3.3. **Assembly and Fitup**. Verify that ends of members to be welded are prepared in accordance with the welded joint detail specified. See Figures 3, 4, and 5 for proper end preparation and weld details of girder splices.

Bring the parts to be joined by fillet welds into as close contact as possible, not separated more than 3/16 in. Increase the leg of the fillet weld by the amount of the separation if the separation is 1/16 in. or more. Keep the separation between faying surfaces of lap joints and of butt joints landing on backing strips to no more than1/16 in.

Make suitable allowance for shrinkage, and never restrain the joint on both sides in any welding process.

Use the following fitup procedure for groove welds for butt joints:

- Align splices of beams and girders joined by groove welds with the center of gravity of both cross-sections coinciding or each flange vertically offset equally. Fit beams and girders with offset webs with the webs aligned and the flanges offset laterally. Make the joint with a smooth transition between offset surfaces and with a slope of no more than1:4 when flanges are offset or abutting parts differ in thickness or width by more than 1/8 in.
- Space members to provide a 3/16-in. root opening at the nearest point. At other points of the joint when the spacing provides up to a 7/16-in. opening, correction may be made by buildup up to 1/8 in. on each bevel nose. Rebevel openings exceeding 7/16 in. and move the parts to be joined closer together to bring the joint within the maximum buildup limits. Allow buildups to cool to the maximum preheat and interpass temperatures before welding the joint.
- Bring all members into correct alignment and hold them in position by acceptable clamps while welding.

Complete all butt splices before welding diaphragms or sway bracing in a particular section of a unit. Diaphragms and sway bracing may be welded in a unit behind the splice welding to provide stability except where such welding interferes with butt splice adjustments, such as at a drop-in segment of a continuous unit. Complete all splices before welding beams or girders to shoes.

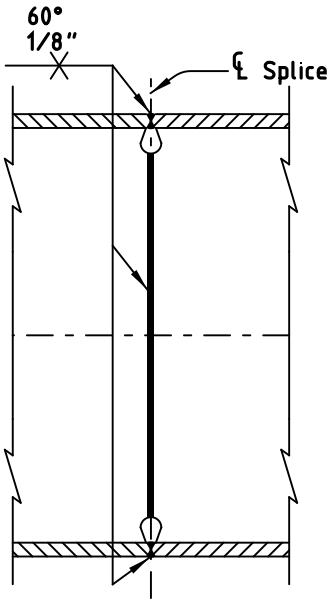


Figure 3
Girder Splice Details

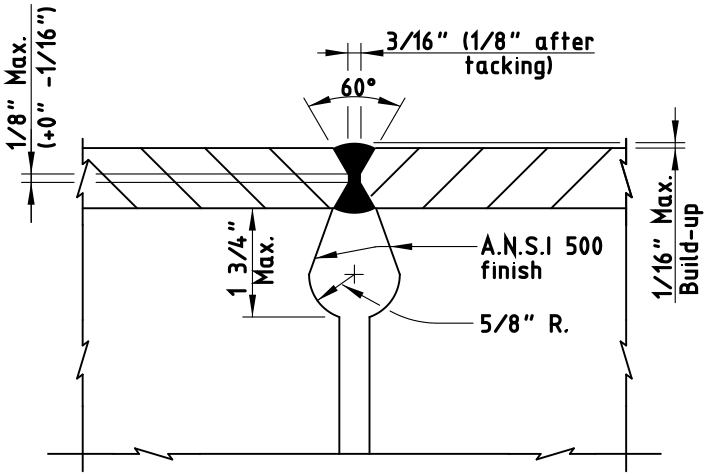


Figure 4
Girder Splice Details (Flange)

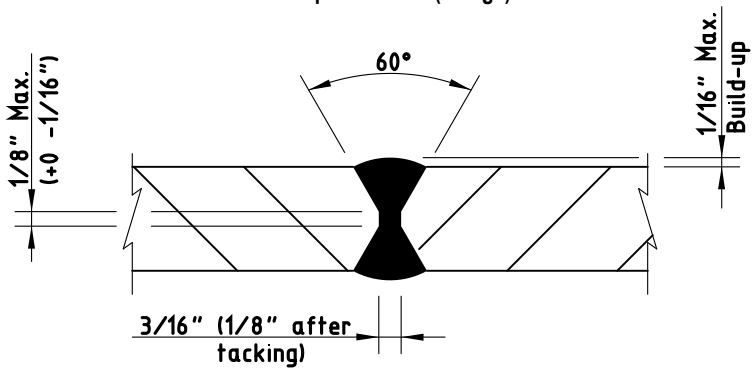


Figure 5
Girder Splice Details (Web)

4.3.4. **Preheat**. Preheat ahead of welding both groove and fillet welds (including tack welding) to the temperatures shown in Table 3. Keep preheat and interpass temperatures high enough to prevent cracks. The preheat

temperatures shown in Table 3 are minimums, and higher preheats may be necessary in highly restrained welds. Preheat the base metal when it is below the required temperature so that parts being welded are not cooler than the specified temperature within 3 in. of the point of welding.

Measure preheat temperature on the side opposite to which the heat is applied at points approximately 3 in. away from the joint.

Completely weld a joint before allowing it to cool below the specified temperature. Always deposit enough weld to prevent cracking before allowing a joint to cool. Do not allow preheat and interpass temperatures to exceed 400°F for thickness up to 1-1/2 in. and 450°F for greater thicknesses.

Table 3
Minimum Preheat and Interpass Temperature for Welding with Low-Hydrogen Electrodes

Thickest Part at Point of Welding	Temperature
Up to 3/4 in., inclusive	50°F
More than 3/4 in. up to 1-1/2 in., inclusive	70°F
More than 1-1/2 in. up to 2-1/2 in., inclusive	150°F
More than 2-1/2 in.	225°F

Preheat the material in accordance with Table 4 when E7010 or E8010 electrodes are used for tacking or temporary root pass.

Table 4
Minimum Preheat Temperature for Welding with E7010 or E8010 Electrodes

Thickest Part at Point of Welding	Temperature
1/2 in. and less	150°F
9/16 in. through 3/4 in.	200°F
13/16 in. through 1-1/2 in.	300°F
More than 1-1/2 in.	400°F

Use preheat and interpass temperatures for the thicker plate thickness when joining steels of different thickness.

Preheat base metal to at least 70°F when the base metal temperature is below 32°F. and maintain this minimum temperature during welding. Preheat base metal to 200°F before starting to weld if it is moist.

Preheat fracture-critical applications in accordance with AASHTO/AWS D1.5.

4.3.5. **Welding Practice**. Use an approved procedure to control shrinkage and distortion. Weld FCAW in accordance with an approved WPS. Weld as required by the Contract or erection drawings. Do not change the location or size of welds without approval. Do not make temporary welds for transportation, erection, or other purposes on main members except as shown on the plans or approved. Use a crayon, paint, or other approved method to mark each groove weld to identify the welder who performed the work.

Use the stringer-bead technique where possible for groove welds. Progress upward in vertical welding passes using a back-step sequence keeping the end of the low-hydrogen electrode contained within the molten metal and shield of flux unless the electrode manufacturer's specifications indicate otherwise.

Begin and terminate groove welds at the ends of a joint on extension bars. Make edge preparation and thickness of extension bars the same as that of the member being welded but extending at least 2 in. beyond the joint. Remove extension bars with a cutting torch or arc-air gouging, and grind the flange edges smooth after the weld is completed and cooled. Clean any defects exposed by the grinding, fill them with weld metal, and regrind them to a uniform finish. Grind so that grind marks are parallel to the flange, and avoid excess grinding of the parent metal. Clean and fuse tack welds thoroughly with the final weld. Remove defective, cracked, or broken tack welds.

Gouge, chip, or otherwise remove the root of the initial weld to sound metal for all groove welds, except those produced with the aid of backing or those on steel piling or armor joints, before welding is started on the second side. Clean the back side thoroughly before placing the backup pass. Fuse the weld metal

thoroughly with the backing, and use backing that is continuous for the full length of the weld. Make a continuous length of backing by welding shorter sections together only under the following conditions:

- All splices in the backing are complete joint penetration (CJP) groove welds made with the same controls as similar CJP groove welds in the structure.
- The welds are radiographed and examined as described in Section 448.4.3.7., "Radiographic Inspection," to ensure weld soundness.
- All welding and testing of the backing is complete before the backing is used to make the structural weld.

4.3.5.1. **High-Cellulose Electrodes for Root Passes**. E7010 and E8010 electrodes may be used when welding the root passes of beam and girder splices if the work is preheated in accordance with Table 4. Remove the E7010 or E8010 electrode pass completely by arc-air gouging, and replace it using a low-hydrogen electrode after the root passes are backed up.

4.3.5.2. **Welding Sequence**. Make beam and girder splices using the sequences shown in Figure 6. (Some members will require fewer or more passes than Figure 6 shows.) Alternate welds from flat to overhead to prevent heat buildup along bevel edge. Arrange the passes between the top and bottom flange to maintain balance and symmetry.

Place passes 1, 2, and 3 in the top flange, followed by passes 4, 5, and 6 in the bottom flange (see Figure 6) for rolled I-beams and built-up girders. Gouge out and replace passes 1 and 4, which always are placed in the overhead position. Next, place passes 7, 8, and 9 in the top flange, followed by passes 10, 11, and 12 in the bottom flange. Continue with placing passes 13–17 in the top flange, followed by passes 18–22 in the bottom flange. Continue to alternate welding between top and bottom flange with a maximum of 5 passes per flange until the flange splices are complete. Tack weld web after aligning girder webs with short tacks as required to obtain proper alignment. Place pass 23 and pass 24 on the web. Gouge out and replace pass 23. Finish web splice with pass 25.

Remove all slag for each layer, bead, and the crater area, and clean the weld and adjacent base metal before welding over previously deposited metal. Avoid arc strikes, and if they occur, grind resulting cracks and blemishes out to a smooth contour, checking them visually to ensure soundness.

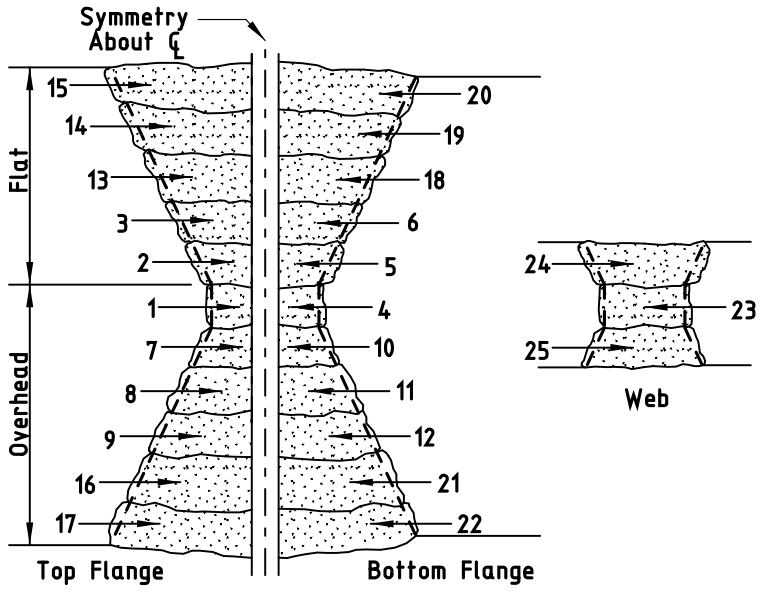


Figure 6
Welding Sequence for Splices for Material up to 50,000-psi Yield Strength.

Deviation from the above sequence of weld passes requires approval. Obtain approval from the Bridge Division for welding procedures and sequences for special connections.

4.3.5.3. **Electrode Size and Weld Layer Thickness**.

4.3.5.3.1. **SMAW**.

4.3.5.3.1.1. **Electrode Size**. Use electrodes with the following maximum size:

- 1/4 in. for all welds made in the flat position except root passes,
- 1/4 in. for horizontal fillet welds,
- 1/4 in. for root passes of fillet welds made in the flat position and of groove welds made in the flat position with backing and with a root opening of 1/4 in. or more,
- 5/32 in. for welds made with low-hydrogen electrodes in the vertical and overhead positions, and
- 3/16 in. for all other welds.

4.3.5.3.1.2. **Weld Size and Layer Thickness**. Make the root pass large enough to prevent cracking. Make layers subsequent to the root pass in fillet welds and all layers in groove welds of the following maximum thickness:

- 1/4 in. for root passes of groove welds;
- 1/8 in. for subsequent layers of welds made in the flat position; and
- 3/16 in. for subsequent layers of welds made in the vertical, overhead, and horizontal positions.

Make fillet welds passes using no larger than:

- 3/8 in. in the flat position,
- 5/16 in. in the horizontal or overhead positions, and
- 1/2 in. in the vertical position.

4.3.5.3.2. **FCAW**.

4.3.5.3.2.1. **Electrode Size**. Use electrodes with the following maximum size:

- 5/32 in. for the flat and horizontal positions,
- 3/32 in. for the vertical position, and
- 5/64 in. for the overhead position.

4.3.5.3.2.2. **Weld Size and Layer Thickness**. Make weld layers, except root and surface layers, no thicker than 1/4 in. Use a multiple-pass split-layer technique when the root opening of a groove weld is 1/2 in. or wider. Use the split-layer technique to make all multiple-pass welds when the width of the layer exceeds 5/8 in.

Ensure each pass has complete fusion with adjacent base metal and weld metal and that there is no overlap, excessive porosity, or undercutting.

Do not use FCAW with external gas shielding in a draft or wind. Furnish an approved shelter of material and shape to reduce wind velocity near the welding to a maximum of 5 mph.

Make fillet weld passes using no larger than:

- 1/2 in. in the flat position,
- 3/8 in. in the horizontal or overhead positions, and
- 5/16 in. in the vertical position.

4.3.6. **Weld Quality**. Provide welds that are sound throughout with no cracks in the weld metal or weld pass. Completely fuse the weld metal and the base metal and each subsequent pass. Keep welds free from overlap, and keep the base metal free from undercut more than 1/100 in. deep when the direction of undercut is transverse to the primary stress in the part that is undercut. Fill all craters to the full cross-section of the welds.

4.3.7. **Radiographic Inspection**. Conduct radiographic testing (RT) as required in the field at the expense of the Contractor by an agency or individual registered and licensed to perform industrial radiography. Follow all applicable rules and regulations for radiographic operations. Testing includes furnishing all materials, equipment, tools, labor, and incidentals necessary to perform the required testing. The Department may require further tests in accordance with Article 5.10., "Inspection," and may perform additional testing, including other methods of inspection.

Perform RT in accordance with AASHTO/AWS D1.5. The Engineer will examine and interpret the resulting radiographs in accordance with AASHTO/AWS D1.5. All radiographs become the property of the Department and remain with the Engineer.

Radiographically inspect the full flange width of all flange splices and the top and bottom 1/6 of the web at each splice for field-welds of splices in beams or girders. Radiographically retest repaired welds. Make necessary repairs before any further work is done. Additional RT required because of unacceptable welding or poor radiograph quality is at the Contractor's expense. RT of particular welds required by the plans is in addition to the RT required by this Item.

Meet the requirements specified in Section 441.3.2.5.1., "Radiographic Testing," for radiograph film quality.

4.3.8. **Corrections**. When welding is unsatisfactory or indicates inferior workmanship, the Engineer will require corrective measures and approve the subsequent corrections.

Use oxygen gouging or arc-air gouging when required to remove part of the weld or base metal. Back-gouge splices in beams and girders or cut out defective welds using arc-air gouging by a welder qualified to make beam and girder splices.

Slope the sides of the area to be welded enough to permit depositing new metal were corrections require depositing additional weld metal.

Use a smaller electrode than that used for the original weld where corrections require depositing additional weld metal. Clean surfaces thoroughly before re-welding.

Remove cracked welds completely and repair. Remove the weld metal for the length of the crack if crack length is less than half the length of the weld plus 2 in. beyond each end of the crack, and repair.

Restore the original conditions where work performed after making a deficient weld has made the weld inaccessible or has caused new conditions making the correction of the deficiency dangerous or ineffectual by removing welds, members, or both before making the necessary corrections; otherwise, compensate for the deficiency by performing additional work according to a revised and approved design.

Cut apart and re-weld improperly fitted or misaligned parts.

Straighten members distorted by the heat of welding using mechanical means or the carefully supervised application of a limited amount of localized heat. Do not let heated areas exceed 1,200°F as measured by temperature-indicating crayons or other approved methods for steel up to 65,000-psi yield strength. Do not let heated areas exceed 1,100°F for higher-strength steels. Keep parts to be heat-straightened substantially free of stress from external forces except when mechanical means are used with the application of heat. Before straightening, submit a straightening procedure to the Engineer for approval.

Correct defective or unsound welds either by removing and replacing the entire weld or as follows:

4.3.8.1. **Excessive Convexity**. Reduce to size by grinding off the excess weld metal, leaving a smooth profile.

4.3.8.2. **Shrinkage Cracks, Cracks in Base Metal, Craters, and Excessive Porosity**. Remove defective portions of base and weld metal down to sound metal, and replace with additional sound weld metal.

4.3.8.3. **Undercut, Undersize, and Excessive Concavity**. Clean and deposit additional weld metal.

4.3.8.4. **Overlap and Incomplete Fusion**. Remove and replace the defective portion of weld.

4.3.8.5. **Slag Inclusions**. Remove the parts of the weld containing slag, and replace them with sound weld metal.

4.3.8.6. **Removal of Base Metal during Welding**. Clean and form full size by depositing additional weld metal using stringer beads.

4.4. **Shear Stud Welding**. Weld shear studs to steel surfaces and perform preproduction and production tests as required in AASHTO/AWS D1.5.

4.5. **Welding Reinforcing Steel**. Splice reinforcing steel by welding only at locations shown on the plans.

4.5.1. **Base Metal**. Provide weldable reinforcing steel in conformance with Item 440, "Reinforcement for Concrete."

4.5.2. **Preheat and Interpass Temperature**. Minimum preheat and interpass temperatures are shown in Table 5. Preheat reinforcing steel when it is below the listed temperature for the size and carbon equivalency range of the bar being welded so that the cross-section of the bar is above the minimum temperature for at least 6 in. on each side of the joint. Allow bars to cool naturally to ambient temperature after welding is complete. Do not accelerate cooling.

Table 5
Minimum Preheat and Interpass Temperature for Reinforcing Steel

Carbon Equivalent Range (%)	Size of Reinforcing Bar (no.)	Temperature (°F)
Up to and including 0.40	Up to 11 inclusive	None
	14 and 18	50
0.41 through 0.45 inclusive	Up to 11 inclusive	None
	14 and 18	100
0.46 through 0.55 inclusive	Up to 6 inclusive	None
	7 to 11 inclusive	50
	14 and 18	200
Unknown	Up to 18 inclusive	500

Base the preheat and interpass temperatures for widening projects on the existing reinforcing steel and the requirements of Table 5.

4.5.3. **Joint Types**. Use butt splices for all No. 7 and larger bars. Use lap splices for No. 6 and smaller bars.

Make groove welds in lap splices at least 4 in. long, and weld them on each side of the lap joint as shown in Figure 7. For No. 5 and smaller bars, weld from one side of the lap when it is impractical to weld from both sides of the joint if approved by the Engineer, but in this case make the weld at least 6 in. long.

Make all butt splices in the flat position. Make all welds for butt splices, except horizontal welds on vertical bars, as shown in Figures 8 and 9. The back-up strip is required when access to the splice is from the top only. When bars can be rotated or access to the splice is available from 2 sides, the double bevel splice may be used, and this type weld requires gouging out the root pass similar to a flange splice on structural steel. The root pass may be made using E7010 or E8010 electrodes for all double beveled splices. Preheat the steel to 400°F, if using E7010 or E8010 electrodes, and then completely remove the root pass before welding the opposite side. Make horizontal splices on vertical bars as shown in Figure 10. Provide alignment strips as shown in Figures 9 and 10 to hold bars during welding operation. Trim alignment strips after welding is complete.

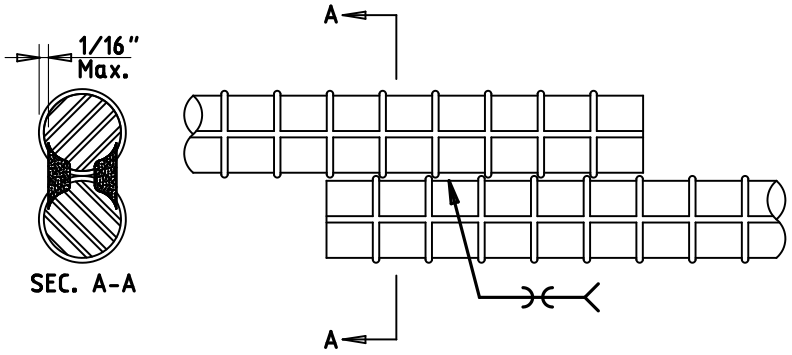


Figure 7
Direct Lap Joint with Bars in Contact

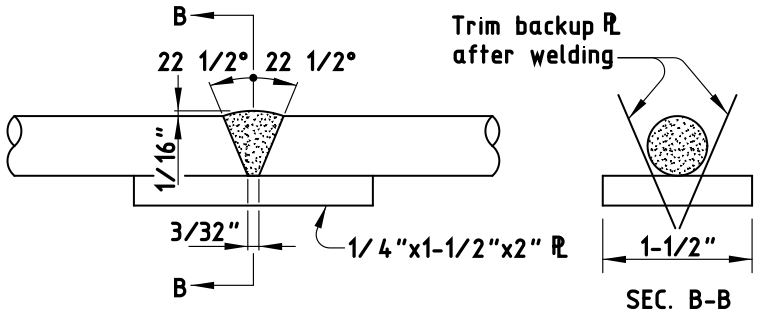


Figure 8
Single Bevel V-Groove Weld in Horizontal Position

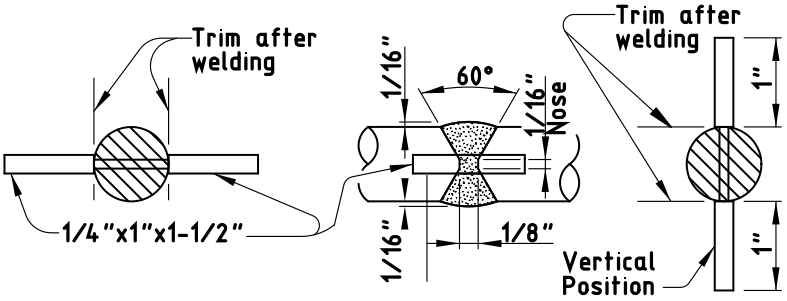


Figure 9
Double Bevel V-Groove Weld in Horizontal Position

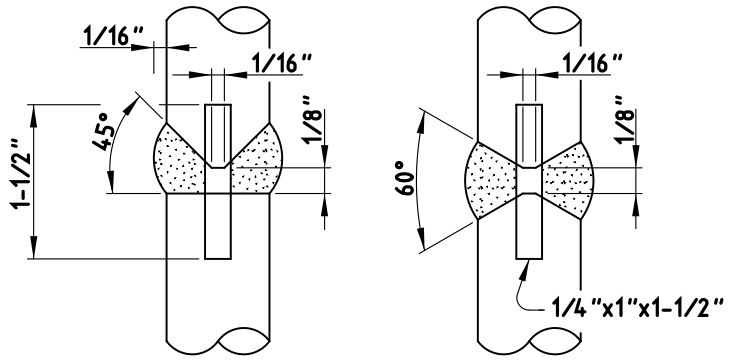


Figure 10
Double Bevel V-Groove Weld in Vertical Position

4.5.4. **Radiographic Inspection**. Radiograph welded butt splices at the expense of the Contractor when designated on the plans. Follow all applicable rules and regulations for radiographic operations. Ensure welds have no cracks and that the sum of the greatest dimensions of porosity and fusion-type defects do not exceed 1/10 of the nominal bar diameter.

The Engineer will examine and interpret the resulting radiographs, which become the property of the Department and remain with the Engineer.

5. MEASUREMENT AND PAYMENT

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

Item 449
Anchor Bolts

1. DESCRIPTION

Fabricate and install anchor bolts to be embedded in or attached to concrete. Anchor bolts are also referred as anchor rods.

2. MATERIALS

2.1. **Bolts and Nuts**. Provide bolts and nuts that meet the standards given in Table 1.

Table 1
Bolt and Nut Standards

Specified Anchor Bolt Category	Bolt Standards	Nut Standards
Mild steel	ASTM A307 Gr. A, F1554 Gr. 36, or A36	ASTM A563
Medium-strength, mild steel	ASTM F1554 Gr. 55 with supplementary requirement S1	ASTM A194 Gr. 2 or A563 Gr. D or better
High-strength steel	ASTM A325 or A449[1]	ASTM A194 or A563, heavy hex
Alloy steel	ASTM A193 Gr. B7 or F1554 Gr. 105	ASTM A194 Gr. 2H or A563 Gr. DH, heavy hex

1. If headed bolts are specified, ASTM A449 bolts must be heavy hex head.

Provide a mill test report or manufacturer's certification indicating the material conforms to these requirements. For alloy steel anchor bolts, provide a test report or certification attesting to the heat-treating process if applicable. If no specific bolt category is indicated on the plans, provide mild steel anchor bolts and nuts that meet the standards given in Table 1.

2.2. **Washers**. Use washers that meet ASTM F436.

2.3. **Threads**. Provide anchor bolts with rolled or cut threads of UNC or 8UN series in accordance with ASME B1.1. Anchor bolts 1-3/4 in. in diameter and larger must have UNC series threads. If bolts have rolled threads, ensure the diameter of the unthreaded portion of bolts with rolled threads is neither less than the minimum pitch diameter nor more than the maximum major diameter of the threads. If bolts have cut threads, ensure the diameter of the unthreaded portion is not less than the minimum major diameter of the threads. Ensure all threads for bolts and nuts have Class 2 fit tolerances in accordance with ASME B1.1.

3. CONSTRUCTION

3.1. **Fabrication**. Welded splicing of anchor bolts is not permitted.

Provide an anchorage device with each anchor bolt consisting of a standard bolt head, a threaded bolt with nuts, or, if shown on the plans, a 90° bend. Make the inside-bend diameter approximately 2 times the anchor bolt diameter, but at no point along the bend greater than 3 times the bolt diameter. Hot bending is permissible provided the temperature does not exceed 1,100°F.

If the anchor bolts will be installed in a template embedded in concrete, tack weld the anchorage nuts to the template in the shop. Perform this welding with appropriate jigs to ensure the anchor bolt is perpendicular to the template.

When embedded templates are not specified and nuts are welded to the end of anchor bolts for anchorage, weld only on the nut face at the unstressed end of the bolt. Ensure no welding, arc, or other potential notch-producing effects occur in the stressed portion of the bolt.

Shipping of the anchor bolt cage in its assembled condition is not required.

3.2. **Finish**. Galvanize in accordance with Item 445, "Galvanizing."

3.2.1. **Anchor Bolts Embedded in Concrete**. Galvanize the exposed end of the thread length plus a minimum of 6 in. unless otherwise shown on the plans.

3.2.2. **Anchor Bolts Extending Through Concrete**. Galvanize the complete length of the bolt.

3.2.3. **Nuts**. Galvanize exposed nuts. Galvanize the untapped blanks before cutting the threads.

3.2.4. **Washers**. Galvanize exposed washers.

3.3. **Installation**. Hold the anchor bolt and template assembly rigidly in position during concrete placement. Use wood templates or other positive means to ensure correct positioning of anchor bolts not requiring steel templates. Positioning devices may be tack welded to the steel templates but not to any portion of the anchor bolts.

3.3.1. **Anchor Bolt Thread Lubricant Coating**. Coat anchor bolt threads before installing nuts with an electrically conducting lubricant compound described in Section 449.3.3.2.1., "Definitions," for traffic signal poles, roadway illumination poles, high mast illumination poles, and overhead sign support structures. Coat anchor bolt threads for other structures with pipe joint compound or beeswax. After installing nuts, repair galvanizing damage on bolts, nuts, and washers in accordance with Section 445.3.5., "Repairs."

3.3.2. **Anchor Bolt Tightening Procedure**. Tighten anchor bolts for traffic signal poles, shoe base and concrete traffic barrier base roadway illumination poles, high mast illumination poles, and overhead sign support structures in accordance with this Section. This procedure covers the tightening of nuts on a double-nut anchor bolt system using anchor bolts with 55 ksi or 105 ksi minimum yield strength and UNC or 8UN thread series to secure structures to drilled shaft foundations.

3.3.2.1. **Definitions**. The following definitions apply to the anchor bolt tightening procedure:

- **Double-Nut Anchor Bolt System**. An anchor bolt with 2 nuts that sandwich the structure's base plate. The bottom nut is positioned under the base plate to level, support, and provide the reaction for the force applied by tightening the top nut positioned above the base plate.
- **Electrically Conducting Lubricant**. A compound commonly used in the electrical industry to coat threads of field-cut rigid metal conduit and suitable for exposure to weather.
- **Impact Tightening**. The tightening of nuts with a box end "slug" or "knocker" wrench and a sledgehammer. The wrench, matching the size of the nut to be tightened, is driven with the sledgehammer to rotate the nut.
- **Static Tightening**. The tightening of nuts with a "spud" wrench and a pipe or extension handle. The wrench, matching the size of the nut to be tightened, may be turned with more than one worker to rotate the nut.
- **Snug-Tight**. The condition when the nut is in full contact with the base plate. It may be assumed the full effort of a worker on a 12-in. wrench results in a snug-tight condition.
- **Turn-of-the-Nut Method**. The tightening of top nuts to snug-tight condition then establishing reference positions by marking one flat on each nut with a corresponding reference mark on the base plate at each bolt. Each nut is then turned to the prescribed rotation from the referenced snug-tight position.

3.3.2.2. **Anchor Bolt Tightening**. Perform the following procedure:

- Coat the threads of the anchor bolts with electrically conducting lubricant.

- Install the bottom nuts on the bolts, 1 on each bolt.
- Level the top template (using it as a guide) by adjusting the bottom nuts so the template rests on each nut and the distance between the top of the concrete shaft and the bottom surface of the bottom nut is approximately 1/2 in.
- Remove the template.
- Coat the bearing surfaces of the bottom nuts and washers with electrically conducting lubricant.
- Install bottom washers on bolts, 1 on each bolt.
- Erect and plumb the structure as specified. Adjust the bottom nuts so each is bearing equally on the washer or base plate. The truss for cantilever overhead sign support structures and the mast arm for traffic signal poles must be removed during anchor bolt tightening.
- With the plumbed structure supported by a crane, coat the bearing surfaces of the top nuts and washers with electrically conducting lubricant. Install 1 washer and 1 top nut on each bolt. Turn the top nuts onto the bolts so each is hand-tight against the washer or base plate.
- Turn each bottom nut to a snug-tight condition using a wrench.
- Verify the structure is still plumb and still supported by the crane. Begin turn-of-the-nut method by turning each top nut down to the same snug-tight condition. Prevent rotation of the bottom leveling nut during all top nut tightening. Establish reference marks for turn-of-the-nut method once snug-tight condition is achieved, and then tighten the top nuts by turning each nut 1/12 turn (1/2 of a nut flat) past snug-tight using either static or impact tightening. Turn each top nut an additional 1/12 turn until each nut has been tightened 1/6 total turn past snug-tight.

4. MEASUREMENT AND PAYMENT

Top or bottom templates, washers, lock washers, nuts, lock nuts, and other devices used for installing anchor bolts are considered part of the anchor bolt assembly. All 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 459
Gabions and Gabion Mattresses

1. DESCRIPTION

Furnish and install gabions and gabion mattresses.

2. MATERIALS

This Item uses the following Items:

- **Gabion**. A wire fabric or mesh container, filled with stone, with a height of 1 ft. or greater.
- **Gabion Mattress**. A wire fabric or mesh container filled with stone and with a height of 6, 9, or 12 in. Referred to as "revet mattress" in ASTM A975.

Furnish welded wire gabions and gabion mattresses in accordance with ASTM A974. Furnish Style 1 or 2 when galvanized wire coating is specified or Style 5 when PVC wire coating is specified.

Furnish twisted wire gabions and gabion mattresses in accordance with ASTM A975. Furnish Style 1 when galvanized wire coating is specified or Style 3 when PVC wire coating is specified.

Furnish producer or supplier certification that wire baskets, stiffeners, lacing wire, and spiral connectors conform to the applicable ASTM specification.

Furnish producer or supplier certification that any alternative wire fasteners that are proposed conform to the strength requirements in Table 1 when tested in accordance with the applicable ASTM specification. Submit certification for approval before beginning work.

Table 1
Minimum Panel-to-Panel Connection Strength

Application	Strength (lb./ft.)
Gabions, galvanized	1,400
Gabions, PVC-coated	1,200
Gabion mattress, galvanized and PVC-coated	700

Provide filler stone consisting of clean, hard, durable stone that does not contain shale, caliche, or other soft particles. Stone appearing to contain such particles will be tested for soundness. Stone with 5-cycle magnesium sulfate soundness of more than 18% when tested in accordance with Tex-411-A will be rejected. Use stones that are between 4 and 8 in. in their least dimension for gabions and between 3 and 6 in. for gabion mattresses. Prevent contamination when storing and handling stone. Use stone with a minimum bulk specific gravity of 2.50 as determined by Tex-403-A.

Provide Type 2 filter fabric when required in accordance with DMS-6200, "Filter Fabric."

Provide filter material when required consisting of hard, durable, clean sand or gravel with a maximum particle size of 3/8 in.

3. CONSTRUCTION

At the start of construction, the gabion and gabion mattress manufacturer must have a qualified representative available for consultation as needed throughout the gabion and gabion mattress construction.

3.1. **Foundation Preparation**. Excavate the foundation to the extent shown on the plans or as directed. Remove all loose or otherwise unsuitable materials. Carefully backfill all depressions to grade with suitable materials

from adjacent required excavation or another approved source, and compact the backfill to a density at least equal to the adjacent foundation. Remove any buried debris protruding from the foundation that will impede the proper installation and final appearance of the gabion or gabion mattress, and carefully backfill and compact voids as specified above. Have the Engineer inspect the prepared foundation surface immediately before gabion placement.

3.2. **Filter Placement**. Spread filter material, when required, uniformly on the prepared foundation surface to the slopes, lines, and grades indicated on the plans. Do not place filter material by methods that tend to segregate particle sizes. Repair all damage to the foundation surface that occurs during filter placement before proceeding with the work. Compaction of the filter material is not required; but, finish the material to present a reasonably even surface without mounds or windrows.

3.3. **Filter Fabric Placement**. Place filter fabric as shown on the plans when required. Any defects, rips, holes, flaws, or damage to the material may be cause for rejection. Place the material with the long axis parallel to the centerline of the structure, highway, or dam. Place securing pins in the lapped longitudinal joints, spaced on approximately 10-ft. centers. Keep the fabric material free of tension, stress, folds, wrinkles, or creases. Lap the material at least 3 ft. along the longitudinal joint of material, or lap the joints 1 ft. and sew them. Lap the ends of rolls at joints by at least 3 ft. Repair torn or punctured fabric by placing a layer of fabric over the damaged area, overlapping at least 3 ft. beyond the damaged area in all directions.

Place securing pins through both strips of material at lapped joints at approximately the midpoint of the overlap. Place additional securing pins as necessary to hold filter fabric in position. Store filter fabric out of direct sunlight. Cover filter fabric as soon as possible after placing, but within 3 days.

3.4. **Assembly and Installation**. Place PVC-coated materials, if wire coating is specified, when the ambient temperature and the temperature of the coated wire are more than 15°F above the brittleness temperature of the PVC.

Assemble empty gabion or gabion mattress units individually, and place them on the approved surface to the lines and grades shown on the plans with the sides, ends, and diaphragms erected to ensure all creases are in the correct position, the tops of all sides are level, and all sides that are to remain exposed are straight and plumb. Fill the basket units after transporting them to their final position in the work.

Place the front row of gabion or gabion mattress units first and successively construct units toward the top of the slope or the back of the structure. Place the initial line of basket units on the prepared surface, and partially fill them to provide anchorage against deformation and displacement during subsequent filling operations. Stretch and hold empty basket units as necessary to remove kinks and provide a uniform alignment. Connect all adjoining empty gabion or gabion mattress units with lacing, wire spiral binders, or approved fasteners along the perimeter of their contact surface to obtain a monolithic structure before filling. Provide continuous stitching with alternating single and double loops at intervals of no more than 5 in. if lacing wire is used. Securely fasten all lacing wire terminals.

Provide connections meeting the joint strength requirements of Article 459.2., “Materials.” These requirements apply to all connections including attachment of end panels, diaphragms, and lids.

Join twisted wire baskets through selvage-to-selvage or selvage-to-edge wire connection; do not use mesh-to-mesh or selvage-to-mesh wire connection except where baskets are offset or stacked, in which case join each mesh opening where mesh wire meets selvage or edge wire.

Carefully fill the basket units with stone, using hand placement to avoid damaging wire coating, to ensure as few voids as possible between the stones and to maintain alignment. Machine placement of stone will be allowed if approved. Correct excessive deformation and bulging of the mesh before further filling. Fill the basket units in a row in stages consisting of maximum 12 in. courses to avoid localized deformation. Do not at any time fill a cell to a depth exceeding 1 ft. more than its adjoining cell. Do not drop stones into the basket units from a height greater than 36 in.

Place 2 uniformly spaced internal connecting wires between each stone layer in all front and side gabion units, connecting the back and the front faces of the compartments for gabion units more than 2 ft. high. Loop connecting wires or preformed stiffeners around 2 twisted wire-mesh openings or a welded wire joint at each basket face, and securely twist the wire terminals to prevent loosening.

Place the outer layer of stone carefully along all exposed faces and arrange it by hand to ensure a neat and compact appearance. Overfill the last layer of stone uniformly by 1 to 2 in. for gabions and 1 in. for gabion mattresses to compensate for future settlement in rock while still allowing for the proper closing of the lid and providing an even surface with a uniform appearance. Make final adjustments for compaction and surface tolerance by hand. Stretch lids tight over the stone fill, using an approved lid-closing tool, until the lid meets the perimeter edges of the front and end panels. Do not use crowbars or other single-point leverage bars for lid closing. Close the lid tightly along all edges, ends, and internal-cell diaphragms with spiral binders or lacing wire or with other wire fasteners if approved. Ensure all projections or wire ends are turned into the baskets. Cut, fold, and wire the basket unit together to suit site conditions where a complete gabion or gabion mattress unit cannot be installed because of space limitations, as shown on the plans, or as directed. Fold the mesh back and neatly wire it to an adjacent basket face. Complete the assembling, installation, filling, lid closing, and lacing of the reshaped gabion or gabion mattress units in accordance with this Section.

4. MEASUREMENT

Gabions will be measured in place by the cubic yard of stone-filled gabions. Gabion mattresses will be measured in place by the square yard of surface area or by the cubic yard.

5. PAYMENT

The work performed and materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for “Gabions” of the basket-wire coating specified, and per square yard of “Gabion Mattresses” of the thickness and basket-wire coating specified or per cubic yard of “Gabion Mattresses” of the basket-wire coating specified.

The price bid is full compensation for wire baskets, stone fill, lacing and fasteners, filter fabric, filter material, excavation, grading and backfill, materials, tools, equipment, labor, and incidentals. Filter fabric and filter material, if used, will not be paid for directly but will be considered subsidiary to this Item.

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 496
Removing Structures

1. DESCRIPTION

Remove and either dispose of or salvage structures.

2. CONSTRUCTION

2.1. **Demolition Plans**. Follow the demolition sequence shown on the plans for bridge structures to be removed, or submit a demolition plan if indicated on the plans. Include in the required demolition plan the type and location of equipment to be used, the method and sequence of removal of the structural elements, and a narrative indicating the stability of the partially demolished structure is maintained throughout the demolition process. Have these plans signed and sealed by a licensed professional engineer when demolished structure intersects active roadways and as otherwise shown on the plans. Submit required demolition plans at least 14 days before starting work unless otherwise directed. Department approval of these plans is not required, but the Department reserves the right to request modifications to the plans when work could affect the safety of the traveling public and when around other transportation facilities to remain in place. Notify the Department 30 days before starting any bridge demolition work to allow for required notifications to other agencies.

2.2. **Removal**.

2.2.1. **Pipes**. Avoid damaging appurtenances determined by the Engineer to be salvageable.

2.2.2. **Concrete, Brick, or Stone Structures**. Portions of structures that will not interfere with the proposed construction may remain in place 2 ft. or more below the permanent ground line. Square off remaining structures and cut reinforcement flush with the surface of the concrete.

2.2.3. **Steel Structures**. Dismantle steel to be retained by the Department or re-erected by cold-cutting fastener heads and punching or drilling the remaining portion of the fastener, air-arc gouging welded connections, and flame-cutting beams along a straight line. The Engineer may approve other methods of cutting. Cut beams at the locations shown on the plans. Match-mark steel to be re-erected with paint in accordance with the erection drawings. Remove steel piles or cut off 2 ft. or more below the permanent ground line.

2.2.4. **Timber Structures**. Remove all fasteners from timber determined by the engineer to be salvageable. Remove timber piles or cut off 2 ft. or more below the permanent ground line.

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

2.4. **Disposal**. Material removed that is not deemed to be salvageable is the property of the Contractor. Dispose of removed material off the right of way in accordance with federal, state, and local regulations.

2.5. **Backfill**. Backfill excavation and voids to the original ground line if resulting from the removal of structures. Place backfill that will support any portion of the roadbed or embankment to the same requirements for placing embankment. Backfill other areas in 10 in. layers, loose measurement, and compact to the density of adjacent undisturbed material.

3. MEASUREMENT

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

4. PAYMENT

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

Item 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 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.”

Special Specification (SS) Item 4007
Pre-Engineered Steel Truss Bridge

1. GENERAL

1.1. These specifications are for a fully engineered clear span bridge of welded steel construction and shall be regarded as minimum standards for design and fabrication for a Pre-engineered, Pre-fabricated Pedestrian / Traffic / Equestrian, and Bicycle Steel Truss Bridge.

1.2. **Description**. This work shall consist of the design, fabrication, storage, delivery and erection of a welded steel truss superstructure. Also included in this work shall be the furnishing and installation of a deck, all bearings, anchors and/or retainers, railings, fencing and miscellaneous items as indicated on the plans.

1.3. **Qualified Suppliers.**

(a) Each bidder is required to identify their intended bridge supplier as part of the bid submittal. Qualified suppliers must have at least 10 years experience fabricating these type structures. Bridge must be "Buy America" approved.

(b) Pre-Approved Manufacturers:
Continental Custom Bridge Company
8301 State Hwy 29 North
Alexandria, Minnesota 56308
800-328-2047, FAX 320-852-7067

(c) Suppliers other than those listed above may be used provided the owner's agent evaluates the proposed supplier and approves the supplier 10 business days prior to bid.

(d) The contractor must provide the following documentation, for any proposed Supplier who is not pre-approved, at least 10 business days prior to bid:

- Product Literature
- All documentation to ensure substitution will be in compliance with these specifications. This shall include:
  Representative drawings with material and design code
  References
  Warranty Information
  AISC Shop Certification
  Welder Qualifications

(e) Proposed suppliers must have at least ten (10) years experience designing and fabricating these type of structures and a minimum of ten (10) successful bridge projects, of similar construction, each of which has been in service at least three (3) years. List the location, bridge size, owner, and a contact for reference for each project.

(f) The owner's agent will evaluate and verify the accuracy of the submittal prior to bid. If the owner's agent determines that the qualifying criteria have not been met, the contractor's proposed supplier shall be rejected. This ruling shall be final.

2. DIMENSIONS

2.1. **Width**: Inside clear width of bridge: Reference plan.

2.2. **Span**: Face of back wall to face of back wall: Reference plan.

2.3. **Camber**: Bridge shall be cambered to offset dead load and appear flat.

3. DESIGN

3.1. **Design Criteria**: Unless noted otherwise, the design of the bridge shall be in accordance with the American Association of State Highway Transportation Officials (AASHTO) "Guide Specifications for Design of Pedestrian Bridges". Tubular members and their connections shall be designed per the AISC "Hollow Structural Sections Connections Manual" latest edition.

In addition to normal dead loads, the bridge shall be designed for the following:

3.2. **Uniform Live Load**: Unless noted otherwise on the plans, pedestrian and bicycle traffic shall be designed in accordance with AASHTO Section 3.14 criteria.

3.3. **Wind Load**: The bridge structure shall be designed for wind loads in accordance with AASHTO section 3 and IBC, whichever will produce the greater effect in the design.

3.4. **Seismic**: All bridges shall be designed for seismic loads of the intensity required by IBC criteria unless specified otherwise.

3.5. **Truck Loads**: HS 20.

3.6. **Other loads:** Reference structural notes.

3.7. **Shop Drawings**: Shop drawings and design calculations shall be prepared and sealed by a professional Engineer registered in Texas and submitted to the owner for approval. The contractor shall be responsible for verification of all field dimensions prior to bridge fabrication. Shop drawings shall include but not limited to design criteria, plans, elevations, sections, details, splices, connections, finishes, and sequence of construction, etc. Shop drawings shall be carefully reviewed and commented by the Contractor prior to submitting to the Engineer for review.

4. MATERIALS

4.1. All structural members shall have a minimum thickness of material in accordance with AASHTO section 10.8.

4.2. Finish of steel bridge shall be as specified on plan:
Unpainted **Weathering Steel** bridges shall be fabricated from ASTM A709 Grade 50 W steel for plates, structural shapes and for tubular sections. Minimum yield (Fy) shall be 50,000 psi.

Painted Steel or **Galvanized** bridges shall be fabricated from ASTM A709 grade 50. Minimum yield (Fy) shall be 50,000 psi.

4.3. **Concrete Floors** - The placing and finishing of 4000 psi concrete and the furnishing of the reinforcement shall be the responsibility of the contractor.

4.4. Field splices shall be bolted with High Strength ASTM A325 bolts; type 3 bolts are required for weathering steel bridges. Galvanized bolts are required for painted and galvanized bridges.

4.5. Welding materials shall be in strict accordance with the American Welding Society (AWS) Structural welding code, D1.1. for tubular members and ANSI/AASHTO/AWS D1.5 Bridge welding code for other structural steel members. Welders will be certified in accordance with the weld process to be used.

5. FABRICATION AND QUALITY CONTROL

5.1. Bridge fabricator shall be certified by the American Institute of Steel Construction to have the personnel, organization, experience, capability, and commitment to produce fabricated structural steel for Conventional Steel Structures and Major Steel Bridges with Sophisticated Paint Endorsement and Fracture Critical Endorsement as set forth in the AISC Certification Program.

5.2. To ensure consistently high levels of quality fabrication, bridge fabricator shall be the designer and supplier of the bridge and shall not assign, sublet, or subcontract any part of bridge fabrication.

5.3. Bridge fabricator shall maintain a full-time Certified Welding Inspector (CWI) on staff for inspection of bridge fabrication, maintaining accurate records, and other necessary aspects of bridge fabrication to ensure consistently high levels of quality fabrication.

5.4. Workmanship, fabrication, and shop connections shall be in accordance with American Association of State Highway and Transportation Officials Specifications (AASHTO).

5.5. Welding operators shall be properly accredited experienced operators, each of whom shall submit satisfactory evidence of experience and skill in welding structural steel with the kind of welding to be used in the work, and who have demonstrated the ability to make uniform good welds meeting the size and type of weld required.

5.6. All welding shall utilize E70 or E80 series electrodes. The weld process used shall be Flux Core Arc Welding (FCAW) or Gas Metal Arc Welding (GMAW) or Shielded Manual Arc Welding (SMAW) or Submerged Arc Welding (SAW) per AWS D1.1 or ANSI/AASHTO/AWS D1.5 “Bridge Welding Code.”

5.7. All welds shall be visually inspected by a Certified Welding Inspector. All testing requirements shall be in accordance with AWS D1.1 for tubular members, and AWS D1.5 for all other structural steel.

6. RAILINGS& ACCESSORIES

6.1. Pedestrian, equestrian, and bicycle railings shall have a smooth inside surface with no protrusions or depressions and shall be in accordance with AASHTO section 2.7. All ends of angles and tubes shall be closed and ground smooth. The following railings are required:

Pedestrian use should be a minimum of 42" above the floor deck.
Bicycle use should be a minimum height of 54" above the floor deck.

7. FINISHES

Blast Cleaning

7.1. All Blast Cleaning shall be done in the fabricator’s OSHA approved indoor facility. Blast operations shall use Best Management Practices and exercise environmentally friendly blast media recovery systems.

Proper personal protective equipment (PPE) shall be used in accordance with OSHA regulations for PPE for blasting operations.

Airborne dust shall be collected by a dust collection system designed for that purpose.

7.2. To aid in providing a uniformly “weathered” appearance Weathering Steel bridges shall have all boldly exposed surfaces abrasive metal blasted in accordance with the Steel Structures Painting Council (SSPC) Surface Preparation Specification No. 7 "Brush-off Blast Cleaning".

Exposed surfaces of steel shall be defined as those surfaces seen from the deck and from outside of the structure. Stringers, wide flange beams, and lower brace diagonals need not be blasted.

Painted bridges shall be abrasive metal blasted in accordance with SSPC SPC-6 or as required by paint system. The bridge shall be painted with an epoxy primer (“Amercoat 240” by Ameron Coatings) followed by an Aliphatic Urethane Gloss Enamel topcoat (“Amershield” by Ameron Coatings) or approved equal. Bridges shall be provided with paint for touch up after erection.

Galvanized bridges shall be have the structural steel galvanized in accordance with AASHTO section 11.3.7 (ASTM A123 for structural steel and ASTM A 153 for galvanized hardware)

8. DELIVERY AND ERECTION

8.1. Bridges will be delivered by truck to a location nearest to the site accessible by roads. Hauling permits and freight charges are the responsibility of the manufacturer.

8.2. The manufacturer will notify the customer in advance of the expected arrival time. Information regarding delays after the trucks depart the plant such as inclement weather, delays in permits, re-routing by public agencies or other circumstances will be passed on to the customer as soon as possible and the expense of such unavoidable delays will be the responsibility of the manufacturer.

8.3. The manufacturer will advise the customer of the actual lifting weights, attachment points and all necessary information to install the bridge. Unloading, splicing, bolting, and proper lifting equipment is the responsibility of the Contractor.

8.4. The construction of the bridge abutments, piers and/or footing shall be by the Contractor. The Contractor shall install the anchor bolts in accordance with the manufacturer's anchor bolt spacing dimensions. All grounding and lightning protection shall be the responsibility of the Contractor.

9. WARRANTY

9.1. The manufacturer shall provide a warranty against defects in material and workmanship for a period of ten years.

10. MEASUREMENT

10.1. The truss superstructure shall be measured in ONE completed and accepted bridge structure and all components within the limit of the truss superstructure as indicated on plans and details.

11. PAYMENT

11.1. The work performed and materials furnished in accordance with this Specification Item and measured as provided under "Measurement" will be paid for at the lump sum price for "Pre-engineered Steel Truss Bridge". This price shall include full compensation for all materials, tools, equipment, labor and incidentals necessary to complete the Work.

11.2. Payment shall be made by the following:
Pay Item SS 4007: Pre-engineered Steel Truss bridge, Including Trusses, Floor Beams, railings, Metal Deck and Concrete Topping per Lump Sum.

GEOTECHNICAL ENGINEERING REPORT

ALPHA TESTING

A UES Company

LAKE SOMERVILLE TRAILWAY BRIDGE REPLACEMENT

SOMERVILLE, TEXAS

GEOTECHNICAL ENGINEERING REPORT

Lake Somerville Trailway Bridge Replacement

Somerville, Texas

Prepared by:

ALPHA TESTING

A UES Company

Alpha Testing

Prepared for:

Texas Parks & Wildlife Department
4200 Smith School Road
Austin, Texas 78744

Attention: Ms. Lyndsi Sandoval

August 15, 2024

UES Project No. 23-0722
TPWD Project No. 1211815

TEXAS ENGINEERING FIRM REGISTRATION NO. F-17076

ALPHA TESTING
A UES Company

August 15, 2024

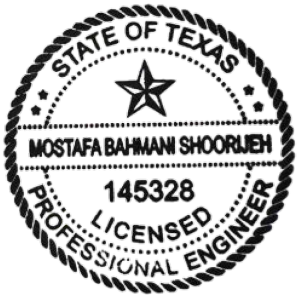
Ms. Lyndsi Sandoval
Texas Parks & Wildlife Department
4200 Smith School Road
Austin, Texas 78744

Re: GEOTECHNICAL ENGINEERING REPORT
Lake Somerville Trailway Bridge Replacement
AUSTIN, TEXAS
UES Project No. 23-0722
TPWD Project No. 1211815

Dear Ms. Sandoval:

Alpha Testing is pleased to submit this Geotechnical Engineering Report for the referenced project. We appreciate the opportunity of working with you. Please contact us if you have any questions or require additional services.

Respectfully submitted,



Mostafa Bahmani, Ph.D., P.E.
Geotechnical Engineer

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TABLE OF CONTENTS

Page

1.0 Introduction 1
2.0 Field Investigation 2
3.0 Laboratory Testing 3
4.0 Site Conditions 4
4.1 Geology 4
4.2 Soil 4
4.3 Groundwater 7
5.0 Analysis and Recommendations 7
5.1 Seismic Site Classification 7
5.2 Soluble Sulfates 7
5.3 Construction Excavations 8
5.4 Groundwater Control 9
5.5 Earthwork 9
5.5.1 Site Preparation 9
5.5.2 Proofroll 10
5.5.3 Wet Weather/Soft Subgrade 10
5.5.4 Fill 10
5.5.5 Construction Monitoring 11
5.6 Demolition Considerations 11
5.7 Loading on Buried Structures 12
5.8 Retaining Structures 12
5.9 Buried Pipe 15
5.10 Slope Stability Analyses 16
5.11 Erosion Protection 18
5.12 Bridge Foundation System 18
5.12.1 Drilled, Straight-Shaft Pier Axial Capacities 19
5.12.2 Auger Cast Piles Axial Capacities 21
5.12.3 Driven Pile Axial Capacity 22
5.12.4 Drilled Pier , Auger Cast Pile and Driven Pile Lateral Capacity 24
5.13 Access Road Pavement 25
5.13.1 Gravel Access Road 25
5.13.2 Pavement Subgrade 26
6.0 General Comments 26

APPENDICES

Appendix A - Project Location Diagrams
Appendix B - Boring Location Diagram
Appendix C - Boring Logs and Laboratory Results
Appendix D - Site Photos
Appendix E - Geologic Information
Appendix F - Axial Capacities of Drilled Piers and Driven Piles
Appendix G - Terms And Symbols Used On Boring Logs
Appendix H - Slope Stability Analysis Results

GEOTECHNICAL ENGINEERING REPORT

Lake Somerville Trailway Bridge Replacement
Somerville, Texas

1.0 INTRODUCTION

Project Location. The site is located at the Lake Somerville Trailway crossings at Nails Creek and Yegua Creek located in the Nails Creek Unit of the Lake Somerville State Park & Trailway, Texas. The general location and orientation of the site are provided in Appendix A - Project Location Diagrams.

Project Description. The work scope includes geotechnical field operations, testing program and engineering analyses for the proposed two bridges at Nails Creek and Yegua Creek.

Project Authorization. This geotechnical investigation was authorized by Ms. Lyndsi Sandoval, Texas Parks & Wildlife Department., dated November 20, 2023, and performed in accordance with Alpha Proposal No. # 100389 P23-1067- Rev3.

Purpose and Methodology. The principal purposes of this investigation were to evaluate the general soil conditions at the proposed site and to develop geotechnical engineering design recommendations. To accomplish its intended purposes, the study was conducted in the following phases:

1. Drill sample borings to evaluate the soil conditions at the boring locations and to obtain soil samples;
2. Conduct laboratory tests on selected samples recovered from the borings to establish the pertinent engineering characteristics of the soils; and
3. Perform engineering analyses, using field and laboratory data, to develop design criteria.

Cautionary Statement Regarding Use of this Report. As with any geotechnical engineering report, this report presents technical information and provides detailed technical recommendations for civil and structural engineering design and construction purposes. ALPHA TESTING, by necessity, has assumed the user of this document possesses the technical acumen to understand and properly utilize information and recommendations provided herein. ALPHA TESTING strives to be clear in its presentation and, like the user, does not want potentially detrimental misinterpretation or misunderstanding of this report. Therefore, we encourage any user of this report with questions regarding its content to contact ALPHA TESTING for clarification. Clarification will be provided verbally and/or issued by ALPHA TESTING in the form of a report addendum, as appropriate.

Report Specificity. This report was prepared to meet the specific needs of the client for the specific project identified. Recommendations contained herein should not be applied to any other project at this site by the client or anyone else without the explicit approval of ALPHA TESTING.

2.0 FIELD INVESTIGATION

Subsurface Investigation. The subsurface investigation for this project is summarized below. Boring locations are provided in Appendix B - Boring Location Diagram.

Boring Nos.	Depth, feet bgs[1]	Date Drilled	Surface Elevation Above (msl)[2], (feet)	GPS Location[2]		Location
				Northing	Easting	
B-01	60	1/10/2024	245	10,087,521.831	3,446,770.873	Nails Creek-North Side
B-02	60	1/19/2024	247	10,087,453.133	3,446,833.652	Nails Creek-South Side
B-03	60	1/4/2024	245	10,098,278.300	3,438,871.492	Yegua Creek-South Side
B-04	60	1/10/2024	246	10,098,330.879	3,438,903.103	Yegua Creek-North Side

Notes:
1. bgs = below ground surface.
2. Boring were not surveyed. The elevations, Northing and Easting of borings were estimated using Google Earth and provided topographic survey by the client.

Boring Logs. Subsurface conditions were defined using the sample borings. Boring logs generated during this study are included in Appendix C - Boring Logs and Laboratory Results. Borings were advanced between sample intervals using continuous flight auger drilling procedures.

Cohesive Soil Sampling. Cohesive soil samples were generally obtained using Shelby tube samplers in general accordance with American Society for Testing and Materials (ASTM) D1587. The Shelby tube sampler consists of a thin-walled steel tube with a sharp cutting edge connected to a head equipped with a ball valve threaded for rod connection. The tube is pushed into the undisturbed soils by the hydraulic pulldown of the drilling rig. The soil specimens were extruded from the tube in the field, logged, tested for consistency using a hand penetrometer, sealed and packaged to maintain "in situ" moisture content.

Consistency of Cohesive Soils. The consistency of cohesive soil samples was evaluated in the field using a calibrated hand penetrometer. In this test a 0.25-inch diameter piston is pushed into the undisturbed sample at a constant rate to a depth of 0.25-inch. The results of these

tests are tabulated at the respective sample depths on the boring logs. When the capacity of the penetrometer is exceeded, the value is tabulated as 4.5+.

Granular Soil Sampling. Granular soil samples were generally obtained using split-barrel sampling procedures in general accordance with ASTM D1586. In the split-barrel procedure, a disturbed sample is obtained in a standard 2-inch outside diameter (OD) split barrel sampling spoon driven 18-inches into the ground using a 140-pound (lb) hammer falling freely 30 inches. The number of blows for the last 12-inches of a standard 18-inch penetration is recorded as the Standard Penetration Test resistance (N-value). The N-values are recorded on the boring logs at the depth of sampling. Samples were sealed and returned to our laboratory for further examination and testing.

Texas Cone Penetration (TCP). Texas Cone Penetration (TCP) test was used to assess the apparent in-place strength characteristics of the soil and rock type materials. In the TCP test procedure, a 3-inch outside diameter (OD) steel cone driven by a 170-pound hammer dropped 24 inches (340 ft-pounds of energy). The number of blows of the hammer required to provide 12 inches of penetration, or the inches of penetration of the cone due to 100 blows of the hammer (whichever occurs first) are recorded on the field logs (reference: TxDOT, Bridge Design Manual).

Groundwater Observations. Groundwater observations are shown on the boring logs.

Borehole Plugging. Upon completion of the borings, the boreholes were backfilled from the top and plugged at the surface.

3.0 LABORATORY TESTING

Alpha Testing performs visual classification and any of a number of laboratory tests, as appropriate, to define pertinent engineering characteristics of the soils encountered. Tests are performed in general accordance with ASTM or other standards and the results included at the respective sample depths on the boring logs or separately tabulated, as appropriate, and included in Appendix C - Boring Logs and Laboratory Results. Laboratory tests and procedures routinely utilized, as appropriate, for geotechnical investigations are tabulated below.

Test Procedure	Description
Tex-103-E	Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass
Tex-104-E	Standard Test Methods for Determining Liquid Limit of Soils
Tex-105-E	Standard Test Methods for Determining Plastic Limit of Soils
Tex-106-E	Standard Test Methods for Calculating the Plasticity Index of Soils
Tex-110-E	Standard Test Method for Particle-Size Analysis of Soils
Tex-111-E	Standard Test Methods for Amount of Material in Soils Finer than the No. 200 (75-µm) Sieve
Tex-118-E	Triaxial Compression Test for Undisturbed Soils
Tex-142-E	Laboratory Classification of Soils for Engineering Purposes
ASTM D2166	Standard Test Method for Unconfined Compressive Strength of Cohesive Soil
ASTM D2487	Standard Classification of Soils for Engineering Purposes (USCS Classification)
ASTM D2488	Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)
ASTM D4220	Standard Practices for Preserving and Transporting Soil Samples
ASTM D4643	Standard Test Method for Determination of Water (Moisture) Content of Soil by the Microwave Oven Method
ASTM D7928	Standard Test Method for Particle-Size Distribution (Gradation) of Fine-Grained Soils Using the Sedimentation (Hydrometer) Analysis

4.0 SITE CONDITIONS

4.1 Geology

Geologic Formation. Based on available surface geology maps, it appears the Nails Creek site is located in the Wellborn Formation near alluvium deposits and the Manning Formation. The Yegua Creek site is located in the Yegua Formation, near the Yegua Formation and the Cadell Formation. A geologic atlas and USGS formation description are provided in Appendix D - . The Wellborn Formation consists generally of sandstone, sand, clay, mud and coal. Soils within the alluvium deposits can generally be characterized as sand, silt, clay and gravel. Soils within the Yegua Formation can generally be characterized as clay with minor beds of sandstone. The Manning Formation consists generally of clay, mud, sand, bentonite, sandstone, siltstone and coal. The Cadell Formation consists generally of siltstone, clay, mud, sandstone and sand.

Geologic Faults. A geologic fault study was beyond the scope of this investigation.

4.2 Soil

Stratigraphy. Descriptions of the various strata and their approximate depths and thickness per the Unified Soil Classification System (USCS) are provided on the boring logs included in Appendix C - Boring Logs and Laboratory Results. A brief summary of the stratigraphy indicated by the borings is provided below.

Generalized Subsurface Conditions at Nails Creek Bridge (Borings B-01 and B-02)			
Nominal Depth, feet bgs (Except as Noted)		General Description	Detailed Description of Soils/Materials Encountered
Top of Layer	Bottom of Layer		
0	10 to 18	PREDOMINTALY CLAYEY SAND	Very soft to hard CLAYEY SAND (SC) and stiff SANDY LEAN CLAY (CL).
10 to 18	53 to 60	CLAY WITH SOME SAND AND GRAVEL SEAMS	Very soft to hard CLAYEY SAND (SC), stiff to very stiff SANDY LEAN CLAY (CL), very soft to stiff SANDY FAT CLAY (CH), stiff to hard FAT CLAY (CH).
53 to 60	60	CLAYEY SAND	Hard CLAYEY SAND (SC).
Note: Boring Termination Depth = 60 feet bgs.			

Generalized Subsurface Conditions at Yegua Creek Bridge (Borings B-03 and B-04)			
Nominal Depth, feet bgs (Except as Noted)		General Description	Detailed Description of Soils/Materials Encountered
Top of Layer	Bottom of Layer		
0	8 to 13	CLAY WITH SOME SAND	CLAYEY SAND (SC), stiff FAT CLAY WITH SAND (CH), soft SANDY FAT CLAY (CH).
8 to 13	60	SAND	Very loose to dense SILTY SAND (SM).
Note: Boring Termination Depth = 60 feet bgs.			

Atterberg Limits and % Passing No. 200. ALPHA TESTING performed Atterberg Limit and percent passing the No. 200 sieve tests on selected samples. The results of the tests are provided in the WinCore Logs included in Appendix C - Boring Logs and Laboratory Results.

Particle Size Distribution Test. ALPHA TESTING performed particle size distribution tests on selected samples. The results of the tests are provided in Appendix C - Boring Logs and Laboratory Results.

Moisture Change Susceptibility of Near Surface Soils. The sandier soils encountered at some locations near the ground surface at this site are very susceptible to changes in moisture. The presence of surface water due to precipitation or groundwater may result in a decrease in the ability to compact and work with the soil. It is common for these soils to pump when subjected to high levels of moisture. In addition, these soils located at and near the ground surface will allow surface water to infiltrate until the water becomes perched on a less permeable layer at depth. Soils of this type are especially prone to requiring the implementation of wet weather/soft subgrade recommendations provided in this report.

Compressive Strength of Rock Samples. Unconsolidated Undrained (U-U) Triaxial strength tests were performed on selected soil samples in accordance with ASTM D2850. Test results are provided in Appendix C - Boring Logs and Laboratory Results and are summarized in the following table.

Unconsolidated Undrained						
Boring No.	Sample Type	Depth (ft.)	Test Method	Moisture Content, (%)	Dry Density (pcf)	Compressive Strength, (tsf)
B-01	Shelby Tube	53 - 55	UU	28.5	96.4	2.64
B-02	Shelby Tube	48 - 50	UU	30.7	93.6	3.23
Note: Cohesionless silty sand (SM) are encountered in B-03 and B-04 and triaxial compression testing are not suitable for this type of soil."						

pH Test Results. Soil pH tests were done according to ASTM 9045D. The pH for the tested samples are summarized in the following table.

Boring No.	Sample Depth (feet, bgs)	Soil Slurry pH	CaCL Slurry pH
B-01	6-8	9.5	10.5
B-02	28-30	8.0	8.1
B-03	6-8	10.2	10.4
B-04	13-15	9.5	10.2

Soluble Sulfate. Soluble sulfate testing was performed in accordance with Tex-145-E for this project. Table below summarizes the soil sulfate content for the tested samples.28-30

Boring No.	Sample Depth (feet, bgs)	Soluble Sulfate Content (ppm)
B-01	6-8	1220
B-02	28-30	1680
B-03	6-8	2440
B-04	13-15	1007

Inorganic Anions. Determination of inorganic anions by chromatography was performed in accordance with SW-846 Method 9056A for this project. Table below summarizes the soil chloride content for the tested samples.

Boring No.	Sample Depth (feet, bgs)	Chloride Content (ppm)
B-01	6-8	101
B-02	23-25	87.2
B-03	6-8	509
B-04	13-15	252

4.3 Groundwater

Groundwater Levels. The borings were advanced using auger drilling and intermittent sampling methods in order to observe groundwater seepage levels. Groundwater levels encountered in the borings during this investigation are identified below.

Boring No.	Depth Groundwater Initially Encountered (feet, bgs)	Groundwater Depth at the end of day (feet, bgs)
B-01	18	18.2
B-02	22	16.5
B-03	15	13.0
B-04	18	18.2

Long-term Groundwater Monitoring. Long-term monitoring of groundwater conditions via piezometers was not performed during this investigation and was beyond the scope of this study. Long-term monitoring can reveal groundwater levels materially different than those encountered during measurements taken while drilling the borings.

Groundwater Fluctuations. Future construction activities may alter the surface and subsurface drainage characteristics of this site. It is difficult to accurately predict the magnitude of subsurface water fluctuations that might occur based upon short-term observations. The groundwater level should be expected to fluctuate throughout the years with variations in precipitation.

5.0 ANALYSIS AND RECOMMENDATIONS

5.1 Seismic Site Classification

The seismic site classification is based on the 2018 International Building Code (IBC) and is a classification of the site based on the type of soils encountered at the site and their engineering properties. Per Table 20.3-1 of ASCE 7-10, the seismic site classification for this site is D.

5.2 Soluble Sulfates

Sulfate/sulfide minerals, when exposed to water, will react with calcium-based additives (lime, cement, and Class CS fly ash) and clay soils to form ettringite. As the mineral ettringite forms, it can expand approximately 2 to 2.5 times its original volume. This process is known as sulfate induced heave and is the cause of swell in the treated subgrade soils and the overlying pavement/slab structure. The table below presents the guidelines provided by the TxDOT for lime treatment and soil sulfate mitigation:

Soluble Sulfate Concentration (ppm)	TxDOT Guidelines for Soil Sulfate Mitigation
0 to 3,000	No restrictions
3,001 to 7,000	In a single application, add the prescribed total amount of lime. Uniformly mix the lime into the soil being treated. Lightly compact the mixture to seal and minimize carbonation. Maintain moisture content above the optimum moisture content of the soil being treated. Three days after the initial addition of lime, determine the soluble sulfate concentration at locations sampled as directed using Tex-145-E, and if the sulfate measurement has been reduced to 3,000 ppm or less, then no additional lime or mellowing time is necessary; however, if sulfate measurement has not been reduced to 3,000 ppm or less, then add 4% additional lime. Uniformly mix the lime into the pretreated soil. Lightly compact the mixture to seal and minimize carbonation and mellow an additional 7 days while maintaining moisture content above optimum. Reprocess the soil-lime mixture to meet the gradation requirements in TxDOT Item 260 - Lime Treatment, Table 1, and compact it at the optimum moisture content.
Greater than 7,000	Subgrade soil should NOT be treated by lime.

Based on the testing results presented in Section 4.2, the sulfate content of tested soil samples is in the range of 1,007 ppm to 2,440 ppm indicating that the levels of sulfate are low. ***Additional sulfate screening testing is recommended to be performed on potential material to receive lime treatment after mass grading has been performed.***

5.3 Construction Excavations

Applicability. Recommendations in this section apply to short-term construction-related excavations for this project.

Sloped Excavations. All sloped short-term construction excavations on-site should be designed in accordance with Occupational Safety and Health Administration (OSHA) excavation standards. The following table addresses OSHA soil type based on the observed soils in the project borings.

OSHA Soil Type by Boring Location and Depth					
Boring No.	Location	Depth of Trench (feet)			
		0-5	5-10	10-15	15-20
B-01	Nails Creek-North Side	C	C	C	C
B-02	Nails Creek-South Side	C	B	C	C
B-03	Yegua Creek-South Side	C	C	C	C
B-04	Yegua Creek-North Side	B	B	C	C

For Type B soils, short-term construction excavations may be constructed with a maximum slope of 1:1, horizontal to vertical (H:V). For Type C soils, short-term construction excavations may be constructed with a maximum slope of 1.5:1. *Per OSHA guideline, for Type B soils*

overlying Type C soils, the excavation should be designed based on Type C soil. For Type C soils overlying Type B soils the excavations should be designed based on the actual soil type encountered. Recommendations provided herein are not valid for any long-term or permanent slopes on-site. We should be contacted to review sloped excavations deeper than 20 feet.

Limitations. Recommendations provided herein assume there are no nearby structures or other improvements which might be detrimentally affected by the construction excavation. Before proceeding, we should be contacted to evaluate construction excavations with the potential to affect nearby structures or other improvements.

Excavation Monitoring. Excavations should be monitored to confirm site soil conditions consistent with those encountered in the borings drilled as part of this study. Discrepancies in soil conditions should be brought to the attention of ALPHA TESTING for review and revision of recommendations, as appropriate.

5.4 Groundwater Control

Groundwater was initially encountered at depths as shallow as 15-feet bgs in borings during drilling and rose to depths as shallow as 13-feet within 8-hours. If groundwater is encountered during excavation, dewatering to bring the groundwater below the bottom of excavations may be required. Dewatering could consist of standard sump pits and pumping procedures, which may be adequate to control seepage on a local basis during excavation. Supplemental dewatering will be required in areas where standard sump pits and pumping is not effective. Supplemental dewatering could include submersible pumps in slotted casings, well points, or eductors. The contractor should submit a groundwater control plan, prepared by a licensed engineer experienced in that type of work.

5.5 Earthwork

5.5.1 Site Preparation

In the area of improvements, all concrete, trees, stumps, brush, debris, septic tanks, abandoned structures, roots, vegetation, rubbish and any other undesirable matter should be removed and properly disposed. All vegetation should be removed and the exposed surface should be scarified to an additional depth of at least 6 inches. It is the intent of these recommendations to provide a loose surface with no features that would tend to prevent uniform compaction by the equipment to be used.

5.5.2 Proofroll

The proof roll should conform to Texas Department of Transportation (TxDOT) Standard Specifications for Construction and Maintenance of Highway, Streets, and Bridges, Item 216 Proof Rolling.

5.5.3 Wet Weather/Soft Subgrade

Soft and/or wet surface soils may be encountered during construction, especially following periods of wet weather. Wet or soft surface soils can present difficulties for compaction and other construction equipment. If specified compaction cannot be achieved due to soft or wet surface soils, one of the following corrective measures will be required:

1. Removal of the wet and/or soft soil and replacement with select fill,
2. Chemical treatment of the wet and/or soft soil to improve the subgrade stability, or
3. If allowed by the schedule, drying by natural means.

Chemical treatment is usually the most effective way to improve soft and/or wet surface soils. ALPHA TESTING should be contacted for additional recommendations if chemical treatment is planned due to wet and/or soft soils. "Lime treatment is an effective solution for addressing clayey soil and mitigating issues with wet or soft subgrades encountered during construction. However, determining the precise amount of lime needed depends on the specific conditions of each case. Based on our experience, we anticipate that a lime application ranging between 4% and 6% (by dry unit weight) will be sufficient to adequately reduce moisture levels in the mixed soil." It is recommended contractor contact TPWD and testing laboratory to determine the amount of lime to be added.

5.5.4 Fill

Embankment Fill. Any new embankment fill material should consist of select fill type material and should have a Plasticity Index between 8 and 25, a Liquid Limit less than 45. Fill should be placed on prepared surfaces in lifts not to exceed 8 inches loose measure. The fill should be compacted to at least 95 percent or more of the Tex-114-E/ASTM D698 maximum dry density at a moisture content recommended in TxDOT Standard Specifications for construction of Highways, Streets and Bridges, Item 132.3 - Embankment, Construction. Prior to any filling operations, samples of the proposed borrow materials should be obtained for laboratory moisture-density testing. The tests will provide a basis for evaluation of fill compaction by in-place density testing.

Fill Restrictions. Fill should consist of those materials meeting the requirements stated. Fill should not contain material greater than 4 inches in any direction, debris, vegetation, waste material, environmentally contaminated material, or any other unsuitable material.

Unsuitable Materials. Materials considered unsuitable for use as select fill or general fill include low and high plasticity silt (ML and MH), silty clay (CL-ML), organic clay and silt (OH and OL) and highly organic soils such as peat (Pt).

5.5.5 Construction Monitoring

Required Testing and Inspections. Construction monitoring services should be provided for all construction activities according to TxDOT Standard Specifications. We recommended that at least three compaction tests be performed for every 4,000 square feet of embankments per lift.

5.6 Demolition Considerations

Applicability. Recommendations in this section apply to the removal of any existing foundations, utilities or pavement which may be present on site.

General. Special care should be taken in the demolition and removal of existing floor slabs, foundations, utilities and pavements to minimize disturbance of the subgrade. Excessive disturbance of the subgrade resulting from demolition activities can have serious detrimental effects on planned foundation and paving elements.

Existing Foundations. Existing foundations are typically slabs, shallow footings, or drilled piers. If slab or shallow footings are encountered, they should be completely removed. If drilled piers are encountered, they should be cut off at an elevation at least 24-inches below proposed grade beams or the final subgrade elevation, whichever is deeper. The remainder of the drilled pier should remain in place. Foundation elements to remain in place should be surveyed and superimposed on the proposed development plans to determine the potential for obstructions to the planned construction. Additional earthwork activities will be required to make the site suitable for new construction if the piers are to be removed completely. Excavations caused by pier removal should be backfilled with hydraulic cement concrete, cement-stabilized sand, or flowable fill. Cement stabilized sand used to backfill pier excavations should meet TxDOT Standard Specifications - Items 275 and 276. Flowable fill used to backfill pier excavations should meet TxDOT Standard Specifications - Item 401, and hydraulic cement concrete should meet TxDOT Standard Specifications - Item 421.

Existing Utilities. Existing utilities and bedding to be abandoned should be completely removed. Existing utilities and bedding may be abandoned in place if they do not interfere with planned development. Utilities which are abandoned in place should be properly pressure-grouted to completely fill the utility.

Backfill. Excavations resulting from the excavation of existing foundations and utilities should be backfilled in accordance with Section 5.4.4 - Fill.

Other Buried Structures. Other types of buried structures (wells, cisterns, etc.) could be located on the site. If encountered, ALPHA TESTING should be contacted to address these types of structures on a case-by-case basis.

5.7 Loading on Buried Structures

Uplift. Buried water-tight structures are subjected to uplift forces caused by differential water levels adjacent to and within the structure. Resistance to uplift pressure is provided by soil skin friction and the dead weight of the structure. Skin friction should be neglected for the upper 3 feet of soil. A skin friction of 200 pounds per square foot (psf) may be used below a depth of 3 feet.

Lateral Pressure. Buried structures should be designed for at-rest lateral earth pressures as provided in table below.

Lateral Earth Pressures			
Location	Condition	Equivalent Fluid Pressure (pcf)	
		Above Groundwater Table	Below Groundwater Table
Nails Creek	At-Rest (k_o)	75	100
Yegua Creek	At-Rest (k_o)	65	95

The above lateral pressures include hydrostatic pressure but do not include surcharge loads. The lateral pressure produced by a surcharge may be computed as 50 percent of the vertical surcharge applied as a constant pressure over the full depth of the buried structure. Surcharge loads set back behind the retaining structure at a horizontal distance equal to or greater than the structure height may be ignored.

Vertical Pressure. Vertical pressures on buried structures due to soil loading can be determined using an equivalent fluid weight of 125 pcf. This does not include surcharge loads. The vertical load produced by a surcharge may be computed as 100 percent of the vertical surcharge pressure applied as a constant pressure over the full width of the buried structure.

5.8 Retaining Structures

General. The retaining walls for the project should be designed and constructed in accordance with the TxDOT Geotechnical Manual and the TxDOT Standard Specifications, Item 423 -

Retaining Walls. Geotechnical recommendations for design of retaining walls are provided in the sections below.

Lateral Earth Pressure. Retaining structure walls should be designed for earth pressures at least to those indicated in this section. Earth pressures will be influenced by the structural design of the walls, conditions of wall restraint, methods of construction and/or compaction, and the strength of the materials being restrained. Two wall restraint conditions are considered. Active earth pressure is commonly used for design of free-standing cantilever retaining walls and assumes wall movement. The at-rest condition assumes no wall movement. The recommended design lateral earth pressures do not include a factor of safety for possible hydrostatic pressure on the walls. ***The values provided in the following table are not applicable to inclined backfill. Any walls with inclined backfill should be designed for an additional equivalent fluid pressure of 1 pcf for every 1 degree of slope inclination.***

Type of Backfill	Active Pressure (pcf)[1] & (2)		At-Rest Pressure (pcf) (1) & (2)	
	Free Draining	Not Free Draining	Free Draining	Not Free Draining
Onsite Fat Clay Soil Unit Weight 125 pcf and Friction Angle of 22° k_a = 0.45; k_o = 0.63	60	90	80	100
Select Fill Soil free of organics and other deleterious material that is compacted to at least 95 percent of the Standard Proctor Density (ASTM D698) and within two percentage points of the optimum moisture content. Unit Weight 125 pcf and Friction Angle of 28° k_a = 0.36; k_o = 0.53	45	85	65	95
Granular Soil - Sands with less than 15% passing no. 200 sieve and compacted to at least 95 percent of the Standard Proctor Density (ASTM D698). Unit Weight 110 pcf and Friction Angle of 32° k_a = 0.3; k_o = 0.47	35	75	50	85
Notes: (1) The values provided are to the nearest 5 pcf. (2) k_a = Coefficient of Active Earth Pressure; k_o = Coefficient of At-Rest Earth Pressure				

Applicable Conditions. For the above earth pressures to be valid, the following conditions apply:

- The equivalent fluid pressure values assume a horizontal ground surface extending backward from the top of the wall;

- For active earth pressure, the wall must rotate around the base, with top lateral movements of about 0.002H to 0.004H, where H is the wall height;
- For passive pressure to develop, the wall must move horizontally to mobilize resistance;
- Horizontal backfill is compacted between 95 and 98 percent of standard Proctor maximum dry density;
- Loading from heavy compaction equipment not included;
- ***No safety factor is included in the soil parameters;***
- ***Appropriate safety factor should be utilized by the structural engineer for external stability (i.e., sliding and overturning) analyses of the retaining structures.***
- The above lateral pressures include hydrostatic pressure but do not include surcharge loads.
- The lateral load produced by a surcharge may be computed as 50 percent of the vertical surcharge pressure applied as a constant pressure over the full depth of retaining wall.
- Surcharge loads set back from the back face of the retaining wall at a horizontal distance equal to or greater than the pile height may be ignored

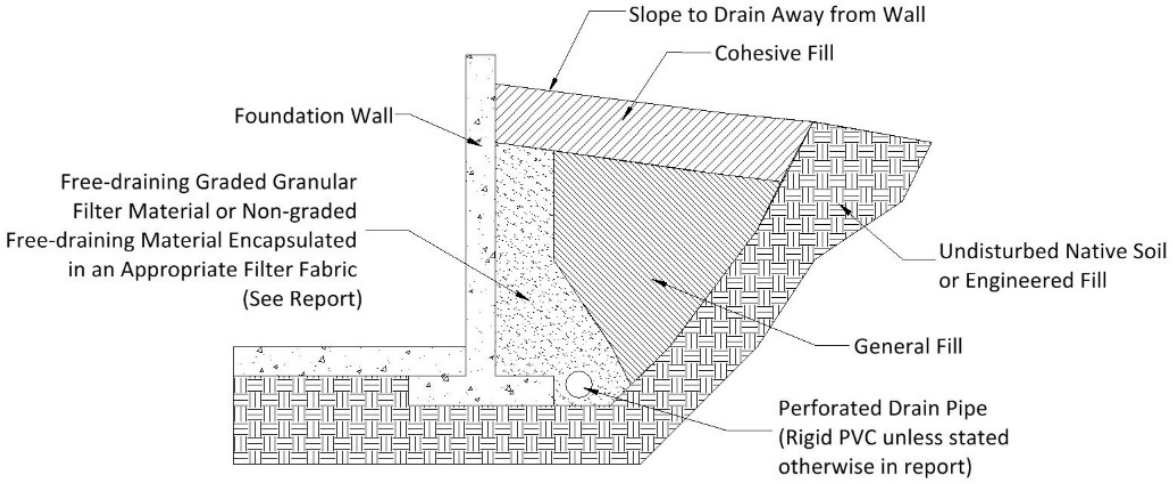
Backfill. Backfill placed against retaining structures may be granular fill or on-site clayey soils. For the granular values to be valid, the granular backfill must extend out from the base of the wall at an angle of at least 45 degrees from vertical. Granular backfill should consist of a clean, non-plastic, relatively well-graded granular soil consisting of either a sand, or a sand and gravel mixture, with less than 5 percent finer than the No. 200 sieve size. To reduce surface water seepage into the free draining backfill, the top 1-ft of the backfill should consist of on-site clay type soil with a plasticity index of at least 15.

Lateral Resistance. Resistance to lateral loads may be provided by the soil adjacent to the structure. We recommend using an equivalent fluid weight of 200 pcf for lateral resistance in soil. A coefficient of sliding friction of 0.3 between the concrete footings and underlying clayey soil may be combined with the passive resistance. *Appropriate safety factor should be utilized by the structural engineer for external stability analyses of the retaining structures*.

Bearing Capacity. Assuming a minimum embedment depth of 24-inches, an allowable bearing capacity of 1,500 psf may be used for retaining structure footings (using a Factor of Safety of 3).

Drainage. A perforated drain line installed behind the base of the walls that extend below adjacent grade is recommended to prevent hydrostatic loading on the walls as shown on the diagram below. The invert of the drain line around a retaining wall should be placed near the foundation bearing level. The drain line should be sloped to provide positive gravity drainage to a sump pit and pump. The drain line should be surrounded by clean, free-draining granular material have less than 5 percent passing the No. 200 sieve. The free-draining aggregate should be encapsulated in a filter fabric. The granular fill should extend to within 2 feet of final grade, where it should be capped with cohesive fill to reduce infiltration of surface water

into the drain system. Underdrains should conform to TxDOT Standard Specifications, Item 556 - Pipe Underdrains. Provide adequate slope to ensure that pipes will drain. Consider the effect of wall foundation elevation changes when setting pipe grades. Increase depth of the underdrain as needed for walls on steep slopes (along the wall face).



Alternative Drainage. As an alternative to free-draining granular fill, a prefabricated drainage system may be used. A prefabricated drainage system may be a plastic drainage core or mesh system which is covered with a filter fabric to prevent soil intrusion and is fastened to the wall prior to placing backfill.

5.9 Buried Pipe

Applicability. Recommendations in this section are applicable to the design of buried piping placed by open cut methods associated with this project.

Pressure on Buried Pipe. Design recommendations provided in section 5.7 - Loading on Buried Structures, of this report apply to buried piping.

Thrust Restraints. Resistance to lateral forces at thrust blocks will be developed by friction developed along the base of the thrust block and passive earth pressure acting on the vertical face of the block. We recommend a coefficient of base friction of 0.3 the base of the thrust block. Passive resistance on the vertical face of the thrust block may be calculated using the allowable passive earth pressures presented below.

Allowable Passive Earth Pressure by Material Type	
Material	Allowable Passive Pressure (psf)
Sand	100 x Depth in Feet
Native Clay and Clayey Sand	2,000
Compacted Clay Fill	1,500
Note: Passive resistance should be neglected for any portion of the thrust block within 3 feet of the final site grade. The allowable passive resistance for native clays and clayey sand is based on the thrust block bearing directly against vertical, undisturbed cuts in these materials.	

Bedding and Backfill. Pipe bedding and pipe-zone backfill for the water and sanitary sewer piping should be in accordance with TxDOT Standard Specifications, Item 400 – Excavation and Backfill for Structures.

Trench Backfill. Trench backfill should be in accordance with TxDOT Standard Specifications, Item 400 - Excavation and Backfill for Structures.

Trench Settlement. Settlement of backfill should be anticipated. Even for properly compacted backfill, fills in excess of 8 to 10 feet are still subject to settlements over time of about 1 to 2 percent of the total fill thickness. This level of settlement can be significant for fills beneath pavements. Therefore, close coordination and monitoring should be performed to reduce the potential for future movement.

5.10 Slope Stability Analyses

General. As presented in the following sections, Alpha performed slope stability analysis and provided geotechnical recommendations along the Nails Creek and Yegua Creek slopes under the proposed bridge abutments.

Stability Analysis Method. The static stability analysis of the Nails Creek and Yegua Creek slopes was performed using GeoStudio 2019© software. The software utilizes multiple slope stability analysis methods to verify consistency of the results. Factors of safety calculated using the *Morgenstern-Price method*, which satisfies both force and moment equilibrium, were utilized.

Recommended Factor of Safety. Based on TxDOT Geotechnical Manual and our experience, the following safety factor were used in slope stability analyses:

Type of Structure	Recommended Safety Factor
Short-Term Conditions	1.50
Long-Term Conditions	1.50
Rapid Drawdown Conditions	1.25

Stability Analysis Soil Parameters. Parameters used in the analyses are presented in the following tables.

Soil Parameters for Stability Analyses – Nail Creek					
Soil Type	Total Unit Weight (pcf)	Short-Term Condition		Long-Term and Rapid Drawdown Conditions	
		C_u (psf) [1]	ϕ_u (deg.) [2]	C' (psf) [3]	ϕ' (deg.) [4]
Onsite Fat Clay	115	800	0	100	22
Onsite Lean Clay/Clayey Sand	125	800	0	90	28

Note:
1. C_u = Undrained Cohesion.
2. ϕ_u = Undrained Friction Angle.
3. C' = Effective Cohesion.
4. ϕ' = Effective Friction Angle.

Soil Parameters for Stability Analyses – Yegua Creek					
Soil Type	Total Unit Weight (pcf)	Short-Term Condition		Long-Term and Rapid Drawdown Conditions	
		C_u (psf) [1]	ϕ_u (deg.) [2]	C' (psf) [3]	ϕ' (deg.) [4]
Onsite Fat Clay	115	800	0	80	22
Onsite Silty Sand	110	0	32	0	32

Note:
1. C_u = Undrained Cohesion.
2. ϕ_u = Undrained Friction Angle.
3. C' = Effective Cohesion.
4. ϕ' = Effective Friction Angle.

Stability Analyses Conditions. The slope stability analyses were performed with a surcharge load of 250 psf for long-term and short-term conditions based on the information provided by the client. No surcharge load was used for rapid drawdown analysis. Based on the provided information, for the rapid drawdown condition, we assumed the water level at the top of the bank will drop to the bottom of creek. For long-term and short-term conditions, we assumed the water level at 2-feet above the bottom of the creeks. Soil erosion at the bottom of the channel will lead to heightening the slope and consequently instability of the slope. To account for future erosion, we considered an additional 2-feet for the height of the bank in our slope stability analysis.

Results of Stability Analyses. The results of our analyses are presented in Appendix H - Slope Stability Analysis Results and summarized in the following tables.

Summary of Slope Stability Analyses					
Location	Slope Required to Achieve FS	Maximum Heigh of Slope (feet)	Computed Factor of Safety		
			Long-Term	Short-Term	Rapid Drawdown
Nail Creek-Abutment 1	3.5H: 1V	17	1.80	2.05	1.25
Nail Creek-Abutment 2	3H: 1V	12	1.89	2.75	1.33
Yegua Creek	3H: 1V	10	1.74	2.99	1.26
Minimum Recommended Factor of Safety			1.50	1.50	1.25

5.11 Erosion Protection

General. Erosion problems are expected especially in the area of high-water velocities, erodible soil and turbulence and slopes should be properly protected from erosion. Excessive erosion may lead to a gradual (progressive) sloughing of side slopes. The embankment slopes should be properly protected from erosion. Rock rip-rap, erosion control fabrics, and/or vegetation may used to protect the slope. Alongside the initial erosion control methods, it's essential to regularly inspect embankments for erosion, especially following heavy rainfall events, and conduct maintenance on areas showing signs of erosion.

5.12 Bridge Foundation System

Appropriate Foundation Types. Based on the geotechnical conditions encountered, drilled straight-shaft piers or driven pile foundations are appropriate for the site. Final determination of the foundation type to be utilized for this project should be made by the Structural Engineer based on loading, economic factors, and risk tolerance.

Note: The contractor's attention is drawn to the hard material in the soil profile, jetting and/or pilot holes may be necessary to advance the piling to the required penetration depth.

The capacities of drilled piers and driven piles were calculated using the procedures described in the Texas Department of Transportation (TxDOT) Geotechnical Manual dated July 2020. The WinCore software program published by TxDOT, which is based on the TxDOT Geotechnical Manual, was used to calculate skin friction and end bearing capacities of drilled piers and driven piles. TCP method was used to calculate the pier and pile capacities in the TxDOT WinCore software program. The TCP method includes a factor of safety of 2.0 for skin friction.

5.12.1 Drilled, Straight-Shaft Pier Axial Capacities

General. The axial capacities of drilled straight-shaft piers are provided in Appendix F - Axial Capacities of Drilled Piers and Driven Piles. A soil reduction factor of 0.7 was used in our analysis.

Maximum Allowable Drilled Shaft Service Loads. The table below presents maximum allowable drilled shaft service loads based on the TxDOT Geotechnical Manual:

Pier Diameter (inches)	Maximum Allowable Service Load (tons)
24	175
30	275
36	400
42	525
48	700
54	900
60	1,100
66	1,350
72	1,600
84	2,175

Capacity Calculations. For each boring, a graph of allowable unit skin friction versus depth was generated. The skin friction capacity curves are included in Appendix F - Axial Capacities of Drilled Piers and Driven Piles. To obtain the frictional capacity for a given shaft, multiply the appropriate unit skin friction value with the embedded surface area; or multiply the appropriate value of accumulative friction in tons per foot at a certain depth with the shaft perimeter. The total allowable axial capacity in compression should be obtained by adding the allowable frictional capacity and the allowable point bearing capacity. The point bearing capacity curves are included in Appendix F - Axial Capacities of Drilled Piers and Driven Piles. **Skin friction capacity of drilled, straight-shaft piers should be neglected along the permanent casing.**

Disregard Depth. To account for potential erosion from scour, future excavation, seasonal soil moisture variation (shrinkage and swelling), lateral migration of waterways, and other factors, ***we recommend neglecting the upper 10-feet of soil in calculating axial capacities.*** Based on the TxDOT Geotechnical Manual, the frictional resistance from any compacted or uncompacted fill materials should be neglected.

Uplift. The uplift force on the piers due to swelling of the active clays can be approximated by assuming a uniform uplift pressure of 1,200 psf acting over the perimeter of the shaft to a depth of 12-feet. The shafts should contain sufficient full length reinforcing steel to resist uplift forces.

Pier Spacing. Piers should not be spaced closer than three shaft diameters, center to center, to utilize the recommended bearing capacities (based on the diameter of the larger shaft). According to the drawings provided by the client, dated February 26th, 2024, the center-to-center spacing ranges between 2 to 3 diameters. A reduction factor of 65 percent should be applied to piles spaced 2 to 3 diameters apart, measured center to center. For piles spaced less than 2 shaft diameters apart, a reduction factor of 40 percent should be used. These reduction factors should be applied to both allowable end bearing and allowable skin friction.

Settlement. Foundation settlement for drilled piers constructed as described herein should be less than 1-inch.

Groundwater. Groundwater was initially encountered at depths as shallow as 15-feet bgs in borings during drilling and rose to depths as shallow as 13-feet within 8-hours. Further, we anticipate groundwater will be encountered during pier excavation and the risk of groundwater seepage is increased during or after periods of precipitation. ***The presence of shallow groundwater indicates that temporary casing and/or slurry displacement method will likely be required for the drilled shafts.*** If groundwater seepage continues after casing installation, water should be pumped out immediately prior to placing concrete. If the groundwater inflow is too severe to be controlled by pumping alone, tremie concrete placement should be employed to ensure displacement of the water. Any loose soil and/or rock fragments from the pier bottom should be removed before placing steel and concrete.

Applicable TxDOT Standards. Drilled pier foundations should be constructed in accordance with the requirements of TxDOT Standard Specifications, Item 416 - Drilled Shaft Foundations. This specification includes requirements for construction using casing or the slurry displacement method, as appropriate.

Construction Observation. The construction of all piers should be observed as a means to verify compliance with design assumptions and to verify:

1. the bearing stratum;
2. the removal of all smear zones and cuttings;
3. that groundwater seepage, when encountered, is correctly handled;
4. that the shafts are vertical (within acceptable tolerance); and
5. to ensure that the top of the shafts in contact with clay are not enlarged (mushroom shaped).

Concrete Placement. Concrete should be placed immediately after the excavation has been completed. Concrete should have a slump of 5 to 7 inches, and should not be allowed to strike the shaft sidewall or steel reinforcement during placement.

5.12.2 Auger Cast Piles Axial Capacities

General. Auger-cast piles are installed by advancing a hollow-stem auger to the desired depth and then pumping high-strength flowable cement grout into the hole through the auger, as the auger is slowly withdrawn. The grout is placed under relatively high pressure, and a positive head of grout is maintained above the bottom of the auger during auger extraction. After the auger is removed, reinforcing steel is placed.

Axial Resistance. For the axial loading design of auger cast piles, we recommend using drilled shaft design procedure established by TxDOT in section 5.12.1 Drilled, Straight-Shaft Pier Axial Capacities.

Uplift. The uplift force on the piers due to swelling of the active clays can be approximated by assuming a uniform uplift pressure of 1,200 psf acting over the perimeter of the pile to a depth of 12-feet. The shafts should contain sufficient full length reinforcing steel to resist uplift forces.

Pile Spacing. Auger-cast piles should not be spaced closer than three shaft diameters, center to center, to utilize the recommended bearing capacities (based on the diameter of the larger shaft). According to the drawings provided by the client, dated February 26th, 2024, the center-to-center spacing ranges between 2 to 3 diameters. A reduction factor of 65 percent should be applied to piles spaced 2 to 3 diameters apart, measured center to center. For piles spaced less than 2 shaft diameters apart, a reduction factor of 40 percent should be used. These reduction factors should be applied to both allowable end bearing and allowable skin friction.

Settlement. Settlement of piles is influenced by a number of factors, including load (pressure), soil consolidation properties, depth to groundwater, geometry (width and length), depth, spacing, and quality of construction. Foundation settlement for piles constructed as described herein should be 1-inch or less.

Pile Load Tests. An auger-cast pile test program may be performed at this site prior to construction. The test program should consist of one test pile per class of pile. If performed, the load tests should be performed in areas unaffected by future foundations. To maximize the working load capacity (and thereby reduce the number of production piles), we recommend the pile load tests be performed to pile failure. If the structure will exert significant lateral loads, it will be necessary to perform a lateral load test. The purpose of the test program is to:

1. Verify equipment and procedures necessary to install the piles.
2. Perform pile load tests to verify the maximum allowable capacity of pile, thereby potentially reducing the number of production piles required for the project.
3. Document pile installation procedures, methods, and results to assist in plan and specification preparation.

4. Reduce the risk to the owner of claimed extra compensation.

Applicable TxDOT Standards. Augered Cast-In-Place Piles should be constructed in accordance with the requirements of TxDOT Standard Specifications, Item 4089 - Augered Cast-In-Place Piles.

Contractor Experience. The performance and success of auger-cast piles is highly dependent on the quality of the installed pile. We recommend a contractor with significant experience in installation of auger-casts piles be retained for the project. Field quality control during construction is also important. Installation procedures, grout pressure, and grout volume should be monitored. Also, contractor proposed alternatives (pile diameter, length, and capacities) should be verified by additional pile load tests at the contractor's expense.

5.12.3 Driven Pile Axial Capacity

General. The axial capacities of driven, square piles are provided in Appendix F - Axial Capacities of Drilled Piers and Driven Piles.

Maximum Allowable Driven Pile Service Loads. The table below presents maximum allowable driven pile service loads based on the TxDOT Geotechnical Manual:

Pile Size (inches)	Maximum Length (feet)	Maximum Allowable Service Load-Abutments and Trestle Bents (tons)	Maximum Allowable Service Load-Footings (Per Pile) (tons)
16	85	75	125
18	95	90	175
20	105	110	225
24	125	140	300

Capacity Calculations. For each boring, a graph of allowable unit skin friction versus depth was generated. The skin friction capacity curves are included in Appendix F - Axial Capacities of Drilled Piers and Driven Piles. To obtain the frictional capacity for a given shaft, multiply the appropriate unit skin friction value with the embedded surface area; or multiply the appropriate value of accumulative friction in tons per foot at a certain depth with the pile perimeter. We recommend the total allowable axial capacity in compression is equal to allowable frictional capacity and the end bearing should be neglected.

Disregard Depth. To account for potential erosion from scour, future excavation, seasonal soil moisture variation (shrinkage and swelling), lateral migration of waterways, and other factors, we recommend neglecting the upper 10-feet of soil in calculating axial capacities. Based on the TxDOT Geotechnical Manual, the frictional resistance from any compacted or uncompacted fill materials should be neglected.

Uplift. The uplift force on the piers due to swelling of the active clays can be approximated by assuming a uniform uplift pressure of 1,200 psf acting over the perimeter of the shaft to a depth of 12-feet. The shafts should contain sufficient full length reinforcing steel to resist uplift forces.

Special Note. Driving refusal maybe encountered during pile driving operation due to the presence of very hard soil layers at this project site. The approximate depths of such layers may exist in each boring location have been shown in the skin friction capacity curves based on the WinCore analysis presented in Appendix E - Axial Capacities of Drilled Piers and Driven Piles. Jetting and/or pilot holes to advance the piling through these soil layers maybe needed.

Pile Spacing. Driven piles should not be spaced closer than three shaft diameters, center to center, to utilize the recommended bearing capacities (based on the diameter of the larger shaft). According to the drawings provided by the client, dated February 26th, 2024, the center-to-center spacing ranges between 2 to 3 diameters. A reduction factor of 65 percent should be applied to piles spaced 2 to 3 diameters apart, measured center to center. For piles spaced less than 2 shaft diameters apart, a reduction factor of 40 percent should be used. These reduction factors should be applied to both allowable end bearing and allowable skin friction.

Settlement: Foundation settlement for driven piles constructed as described herein should be less than 1-inch.

Applicable TxDOT standard Precast Concrete Pile Requirements. We recommend the precast concrete piles meet the requirements outlined in the Texas Department of Transportation Standard Specifications Item 409 “Prestressed Concrete Piling”.

Applicable TxDOT standards Steel Pipe Pile Requirements. Proposed steel pipe piles for the project should be designed and constructed in accordance with the TxDOT Geotechnical Manual and the TxDOT Standard Specifications, Item 407, “Steel Piling”.

Pile Driving and Quality Control. We recommend the pile driving operations and quality control during piles driving operations should confirm to the specifications provided in the Texas Department of Transportation Standard Specifications Item 404 “Driving Piling”. Close field supervision should be maintained by experienced personnel to ensure proper procedures are followed and accurate records are kept during all pile driving operations. The driving record should include the hammer model, driving energy, pile type, overall length, pile size (side dimensions), and number of blows per foot of penetration. An accurate driving record is especially important to verify all piles are installed to the required tip embedment and to give an indication of any unusual driving characteristics which may indicate pile breakage.

5.12.4 Drilled Pier , Auger Cast Pile and Driven Pile Lateral Capacity

Lateral Resistance. The project structural engineer should perform the lateral analysis of drilled piers. ***The lateral resistance values provided below are valid for soils below a depth of 5 feet below finished grade.***

L-PILE Design Parameters by Material Type - (Borings B-01 to B-04)	
Material Type	L-PILE Parameters
Engineered Fill & Medium Clays & Clayey Sand (With Texas Cone Penetration (TCP) less than 20 blows per foot)	Soil Type: Medium Clay Moist Soil Unit Weight: 125 pcf Undrained Cohesion: 500 psf Strain @ ½ Peak Strength (ε50): 0.01 p-y Modulus (k): 100 pci (static)
Stiff Clays (With TCP between 20 to 40 blows per foot)	Soil Type: Stiff Clay Effective Soil Unit Weight: 125 pcf Undrained Cohesion: 1,000 psf Strain @ ½ Peak Strength (ε50): 0.007 p-y Modulus (k): 500 pci (static), 200 pci (cyclic)
Submerged Stiff Clays (With TCP between 20 to 40 blows per foot)	Soil Type: Stiff Clay Effective Soil Unit Weight: 75 pcf Undrained Cohesion: 1,000 psf Strain @ ½ Peak Strength (ε50): 0.007 p-y Modulus (k): 500 pci (static), 200 pci (cyclic)
Very Stiff Clays (With TCP greater than 40 blows per foot)	Soil Type: Very Stiff Clay Moist Soil Unit Weight: 125 pcf Undrained Cohesion: 2,000 psf Strain @ ½ Peak Strength (ε50): 0.005 p-y Modulus (k): 1000 pci (static), 400 pci (cyclic)
Submerged Very Stiff Clays (With TCP greater than 40 blows per foot)	Soil Type: Submerged Very Stiff Clay Moist Soil Unit Weight: 75 pcf Undrained Cohesion: 2,000 psf Strain @ ½ Peak Strength (ε50): 0.005 p-y Modulus (k): 1000 pci (static), 400 pci (cyclic)
Medium Dense Sand Above the Water Table (With TCP between 20 to 40 blows per foot)	Soil Type: Medium Dense Sand Effective Soil Unit Weight: 110 pcf Friction Angle (ϕ): 34 degrees p-y Modulus (k): 90 pci (cyclic)
Medium Dense Submerged Sand (With TCP between 20 to 40 blows per foot)	Soil Type: Medium Dense Submerged Sand Effective Soil Unit Weight: 50 pcf Friction Angle (ϕ): 34 degrees p-y Modulus (k): 60 pci (cyclic)
Dense Sand Above the Water Table (With TCP greater than 40 blows per foot)	Soil Type: Dense Submerged Sand Effective Soil Unit Weight: 110 pcf Friction Angle (ϕ): 40 degrees p-y Modulus (k): 225 pci (cyclic)
Dense Submerged Sand (With TCP greater than 40 blows per foot)	Soil Type: Dense Submerged Sand Effective Soil Unit Weight: 50 pcf Friction Angle (ϕ): 40 degrees p-y Modulus (k): 125 pci (cyclic)

According to the guidelines in Section 4.6.5.6.1.4 of AASHTO (1996), drilled shafts can be treated as acting independently under lateral loads if the spacing between their centers is more than 2.5 diameters in the direction perpendicular to the load and more than 8 diameters in the direction parallel to the load. If these spacing conditions are not met, the design should account for shaft interaction effects. According to the drawings provided by the client, dated February 26th, 2024, the center-to-center spacing ranges between 2 to 3 diameters in the direction parallel to the load. For piles spaced 2 to 3 diameters apart (center to center), a reduction factor of 60% should be applied.

5.13 Access Road Pavement

Recommendations for gravel pavement and preparation of the pavement subgrade are provided in the following sections. Based on the information provided by the client, we understand the access road will be typically used for hikers and horseback riders. TWPD pickup trucks and maintenance equipment will be infrequent and limited to a couple of times a week. Heavier emergency vehicle traffic (i.e., ambulances, fire trucks, water trucks, etc.) will be on an emergency as needed basis. A detailed traffic study indicating the number and type of vehicles on which to base the pavement design was not provided. Therefore, our recommendations are based upon our experience with similar projects assuming normal vehicular loading.

5.13.1 Gravel Access Road

General. As requested, provided herein are our gravel road design recommendations for the proposed bridge access road. The following crushed aggregate pavement section are recommended:

Option	Minimum Crushed Aggregate Base Thickness (inches)	Subgrade
1	8	8-Inches chemical Stabilized Soil
2	8	Tensar Geogrid Biaxial Type 2 or equivalent
Note: 1. Chemical stabilized soil treatment recommendation is provided in section 5.11.2.		

The crushed aggregate base should comply with TxDOT Standard Specifications, Item 247, Type D, Grade 1-2, or local equivalent. *Routine maintenance of the crushed aggregate pavement will be required and often increases the design life significantly. Should any potholes arise, immediate repair is required.* ***Surface water drainage will be crucial to the performance of pavements. Standard construction practices of providing good surface water drainage should be used.*** *A positive slope of the ground away from any pavement should be provided.*

Ditches, swales, or French drains should be provided to carry the run-off water both during and after pavement construction.

5.13.2 Pavement Subgrade

Subgrade Preparation. Fat clay may be encountered or exposed at pavement subgrade. The pavement subgrade should be placed in loose lifts not exceeding 8-inches and should be uniformly compacted to a minimum of 95 percent maximum dry density (per ASTM D-698) and within ±2 percent of the optimum moisture content. We recommend the subgrade be stabilized using the following:

Reagent	Application Rate (pounds per square yard)	Application Depth (inches)
Lime	36	8

Lime stabilization should be performed in accordance with TxDOT Standard Specifications, Item 260, "Lime Stabilized Subgrade", or local equivalent.

Cautionary Note Regarding Stabilized Subgrades. Stabilized subgrades are not suitable for supporting heavy construction traffic. Stabilized subgrades that have been subjected to heavy construction traffic should be re-inspected and re-stabilized as necessary prior to the construction of overlying pavement.

6.0 GENERAL COMMENTS

Data Assumptions. By necessity, geotechnical engineering design recommendations are based on a limited amount of information about subsurface conditions. In the analysis, the geotechnical engineer must assume subsurface conditions are similar to those encountered in the borings. The analyses, conclusions and recommendations contained in this report are based on site conditions as they existed at the time of the field investigation and on the assumption that the exploratory borings are representative of the subsurface conditions throughout the site; that is, the subsurface conditions everywhere are not significantly different from those disclosed by the borings at the time they were completed.

Subsurface Anomalies. Anomalies in subsurface conditions are often revealed during construction. If during construction, different subsurface conditions from those encountered in our borings are observed, or appear to be present in excavations, we must be advised promptly so that we can review these conditions and reconsider our recommendations where necessary.

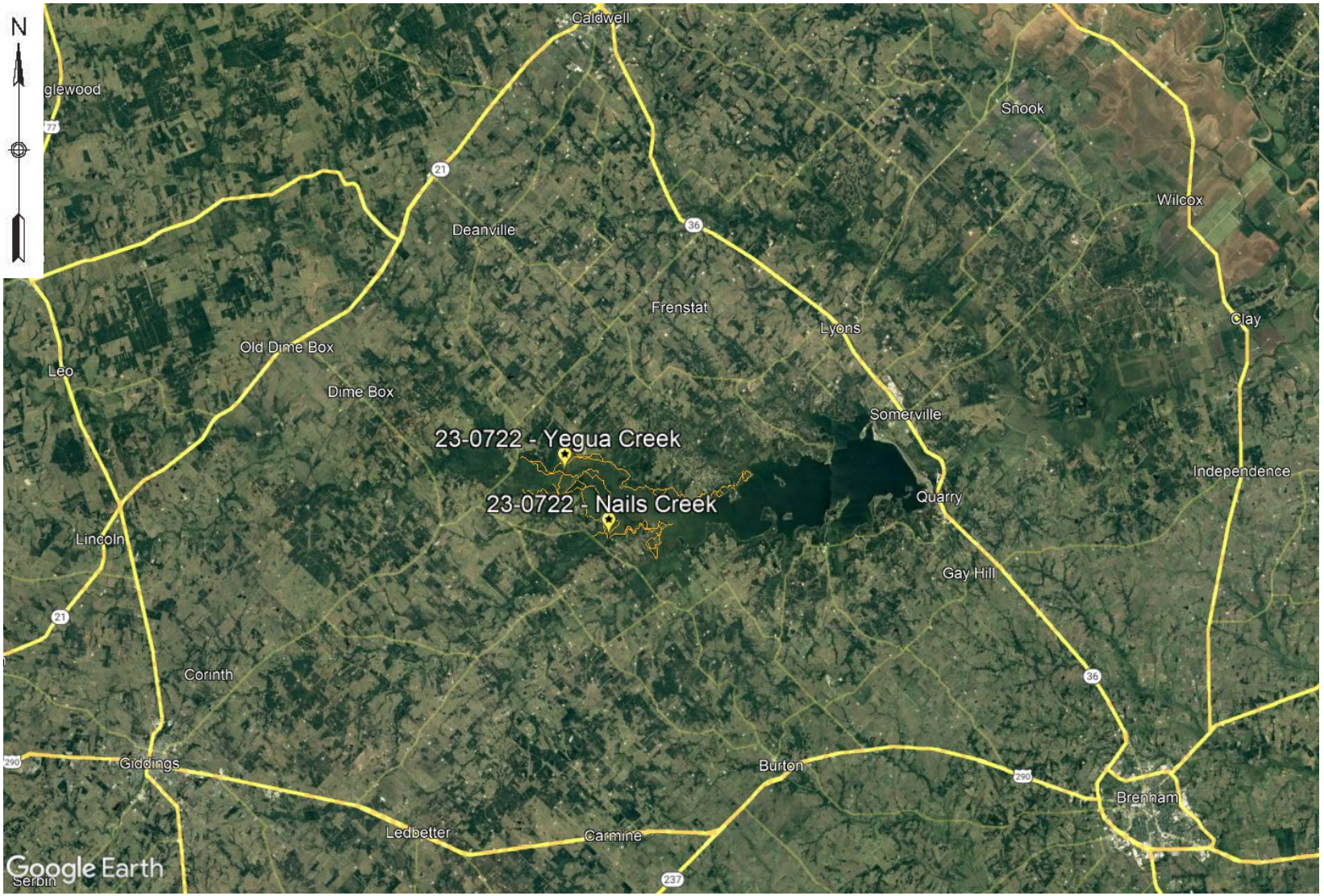
Change of Conditions. If there is a substantial lapse of time between submission of this report and the start of the work at the site, if conditions have changed due either to natural causes or to construction operations at or adjacent to the site, or if structure locations, structural

loads or finish grades are changed, we should be promptly informed and retained to review our report to determine the applicability of the conclusions and recommendations, considering the changed conditions and/or time lapse.

Warranty. This report has been prepared for the exclusive use of the Client and their designated agents for specific application to design of this project. We have used that degree of care and skill ordinarily exercised under similar conditions by reputable members of our profession practicing in the same or similar locality. No other warranty, expressed or implied, is made or intended.

Appendix A - Project Location Diagrams

PROJECT LOCATION DIAGRAM - GENERAL



Project No. 23-0722

Lake Somerville Trailway Bridge Replacement

PROJECT LOCATION DIAGRAM - LOCAL

Project No. 23-0722

Lake Somerville Trailway Bridge Replacement

Appendix B - Boring Location Diagram

BORING LOCATION DIAGRAM – NAILS CREEK

Project No. 23-0722

Lake Somerville Trailway Bridge Replacement

BORING LOCATION DIAGRAM – YEGUA CREEK

Project No. 23-0722

Lake Somerville Trailway Bridge Replacement

Appendix C - Boring Logs and Laboratory Results

DRILLING LOG

WinCore Version 3.3	County	Hole	B-01	District	Somerville
	Highway	Structure	Bridge	Date	1/10/2024
	CSJ	Station		Grnd. Elev.	0.00 ft
		Offset		GW Elev.	-18.00 ft

Elev. (ft)	LOG	Texas Cone Penetrometer	Strata Description	Triaxial Test Lateral Press. (psi)	Triaxial Test Deviator Stress (psi)	Properties MC	Properties LL	Properties PI	Properties Wet Den. (pcf)	Additional Remarks
			SAND, clayey, very soft to soft, brown. (SC)			22	33	14		PP = 2.50, -#200 = 42%
										PP = 1.50
5		5 (6) 4 (6)				16				PP = 2.50
										PP = 2.50
10		3 (6) 5 (6)								N = 3-2-2(4)
-13.			CLAY, sandy, very soft to stiff, brown, with gravel at 18-ft. (CH)							
15		3 (6) 3 (6)				26	52	29		N = 3-6-6(12), -#200 = 70%
20		5 (6) 5 (6)								N = 9-4-3(7)
25		10 (6) 19 (6)				26				N = 8-12-17(29)
-28.			CLAY, very stiff to hard, dark gray, with sand seams. (CH)							
30		23 (6) 25 (6)								PP = 4.50+
35		23 (6) 36 (6)				34	72	45		PP = 4.50+, -#200 = 95%
40		25 (6) 38 (6)				28				PP = 4.50+
45		33 (6) 34 (6)								PP = 4.50+
50		35 (6) 40 (6)				31				PP = 4.50+
55		45 (6) 50 (5)		19.5	36.7	28				PP = 4.50+
-60. 60		50 (5.5) 50 (5.5)				40				N = 13-15-29(44)

Remarks: Auger 0- to 60-feet. SPT tests were performed with a 170-lb hammer dropped 24-inches. .

Any ground water elevation information provided on this boring log is representative of conditions existing on the day and for the specific location where this information was collected. The actual groundwater elevation may fluctuate due to time, climatic conditions, and/or construction activity.

Driller: RINER **Logger: J.A.** **Organization: RINER**

DRILLING LOG

	County	Hole	B-02	District	Somerville
WinCore	Highway	Structure	Bridge	Date	1/19/2024
Version 3.3	CSJ	Station		Grnd. Elev.	0.00 ft
		Offset		GW Elev.	-22.00 ft

Elev. (ft)	LOG	Texas Cone Penetrometer	Strata Description	Triaxial Test Lateral Press. (psi)	Triaxial Test Deviator Stress (psi)	Properties MC	Properties LL	Properties PI	Properties Wet Den. (pcf)	Additional Remarks
-2.			SAND, clayey, brown, with gravel. (SC)			20				
			CLAY, sandy, stiff, brown. (CL)			14	43	22		PP = 4.50+, -#200 = 53%
		20 (6) 17 (6)								PP = 4.50+
5										
-8.										PP = 4.50+
			SAND, clayey, stiff to very stiff, brown. (SC)			15	45	31		PP = 4.50+, -#200 = 44%
10		22 (6) 25 (6)								
		10 (6) 14 (6)				17				PP = 2.00, -#200 = 44%
15										
-18.										
		15 (6) 16 (6)	CLAY, stiff to hard, dark gray, with sand seams. (CH)			40	52	37		PP = 2.50, -#200 = 97%
20										
		25 (6) 35 (6)								N = 13-18-22(40)
25										
		35 (6) 37 (6)								PP = 4.50+
30										
		50 (3.5) 50 (3)				31				PP = 4.50+, -#200 = 90%
35										
		50 (3.5) 50 (3.5)								PP = 4.50+
40										
		50 (3) 50 (3)								PP = 4.50+
45										
		50 (3.5) 50 (3)		16.5	44.9	31				PP = 4.50+
50										
-53.			SAND, clayey, hard, dark gray. (SC)							
		50 (3.5) 50 (3.5)								N = 27-42-47(89)
55										
-60.		50 (3.5) 50 (3.5)								N = 18-24-30(54)
60										

Remarks: Auger 0- to 60-feet. SPT tests were performed with a 170-lb hammer dropped 24-inches. .

Any ground water elevation information provided on this boring log is representative of conditions existing on the day and for the specific location where this information was collected. The actual groundwater elevation may fluctuate due to time, climatic conditions, and/or construction activity.

Driller: RINER **Logger: J.A** **Organization: RINER**

DRILLING LOG

	County	Hole	B-03	District	Somerville
WinCore	Highway	Structure	Bridge	Date	1/4/2024
Version 3.3	CSJ	Station		Grnd. Elev.	0.00 ft
		Offset		GW Elev.	-15.00 ft

Elev. (ft)	Texas Cone Penetrometer	Strata Description	Triaxial Test: Lateral Press. (psi)	Triaxial Test: Deviator Stress (psi)	Properties: MC	LL	PI	Wet Den. (pcf)	Additional Remarks
		CLAY, with sand, stiff, brown and light brown. (CH)			19				N = 2-10-10(20)
					12	55	34		N = 7-9-8(17), -#200 = 74%
5	12 (6) 13 (6)								N = 11-14-9(23)
-8.		SAND, silty, very loose to dense, brown and gray. (SM)							PP = 2.50
10	4 (6) 4 (6)				18				
15	1 (6) 1 (6)				27				N = 1-1-1(2), -#200 = 23%
20	2 (6) 2 (6)								N = 1-1-1(2)
25	13 (6) 24 (6)				33				N = 7-11-18(29), -#200 = 16%
30	50 (6) 43 (6)								N = 18-23-24(47)
35	50 (3) 50 (2)				16				N = 20-37-28(65)
40	50 (4) 50 (1.25)								N = 34-50/5.75 in.
45	50 (3.75) 50 (3)				31				N = 13-26-34(60), -#200 = 19%
50	50 (3.5) 50 (2.75)								N = 50/5.75 in.
55	50 (3.25) 50 (3.5)				27				N = 20-27-36(63)
-60. 60	50 (3) 50 (3)				31				N = 24-31-27(58), -#200 = 21%

Remarks: Auger 0- to 60-feet. SPT tests were performed with a 170-lb hammer dropped 24-inches. .

Any ground water elevation information provided on this boring log is representative of conditions existing on the day and for the specific location where this information was collected. The actual groundwater elevation may fluctuate due to time, climatic conditions, and/or construction activity.

Driller: RINER **Logger: J.C.** **Organization: RINER**

DRILLING LOG

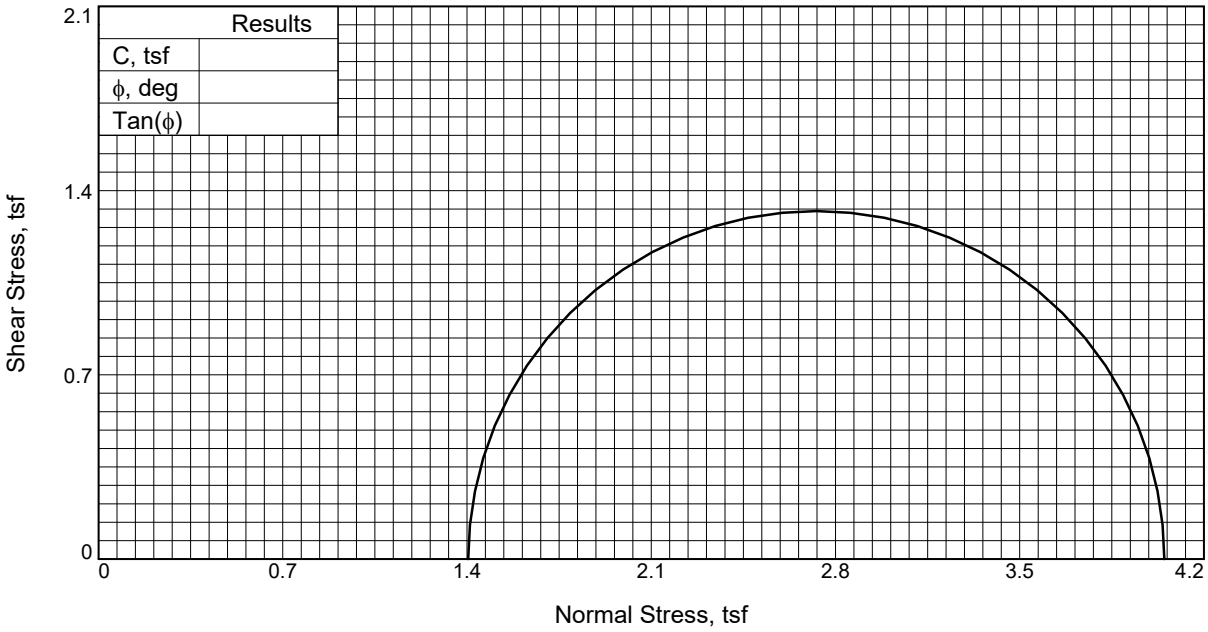
	County	Hole	B-04	District	Somerville
WinCore	Highway	Structure	Bridge	Date	1/10/2024
Version 3.3	CSJ	Station		Grnd. Elev.	0.00 ft
		Offset		GW Elev.	-18.00 ft

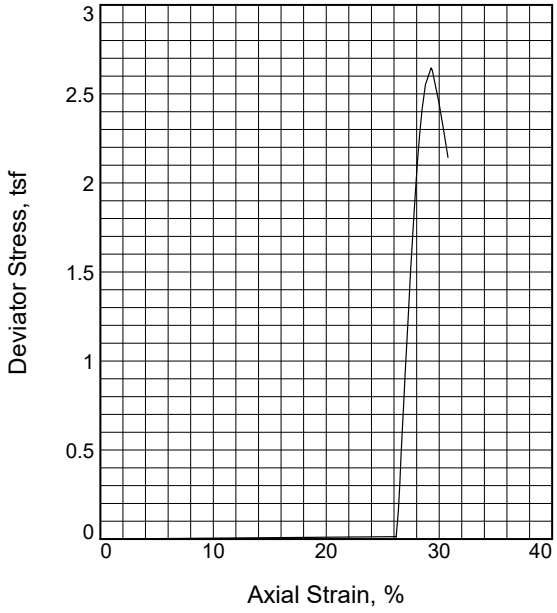
Elev. (ft)	Texas Cone Penetrometer	Strata Description	Triaxial Test: Lateral Press. (psi)	Triaxial Test: Deviator Stress (psi)	Properties: MC	Properties: LL	Properties: PI	Properties: Wet Den. (pcf)	Additional Remarks
-2.		SAND, clayey, brown. (SC)			12	59	36		PP = 3.00, -#200 = 20%
		CLAY, sandy, soft, brown and light brown, with gravel. (CH)							PP = 4.50+
5	10 (6) 10 (6)				10				PP = 4.50+
					20	61	41		PP = 4.00, -#200 = 80%
10	8 (6) 6 (6)				15				PP = 1.50
-13.		SAND, silty, very loose to dense, light brown and gray. (SM)							
15	3 (6) 3 (6)				28				
20	2 (6) 2 (6)				25				-#200 = 12%
25	13 (6) 24 (6)								N = 16-16-10(26)
30	50 (6) 45 (6)				30				N = 24-50/4.5 in.
35	50 (3) 50 (3)				25				N = 7-27-31(58), -#200 = 12%
40	50 (4) 50 (4)								N = 24-32-40(72)
45	50 (3.25) 50 (3)				26				N = 23-25-35(60), -#200 = 18%
50	50 (3.5) 50 (3.5)								N = 7-24-33(57)
55	50 (3.25) 50 (3.5)				25				N = 8-19-25(44), -#200 = 18%
-60. 60	50 (3) 50 (3)								N = 13-24-32(56)

Remarks: Auger 0- to 60-feet. SPT tests were performed with a 170-lb hammer dropped 24-inches. .

Any ground water elevation information provided on this boring log is representative of conditions existing on the day and for the specific location where this information was collected. The actual groundwater elevation may fluctuate due to time, climatic conditions, and/or construction activity.

Driller: RINER **Logger: J.C.** **Organization: RINER**





Sample No.		1
Initial	Water Content, %	28.5
	Dry Density, pcf	96.4
	Saturation, %	
	Void Ratio	0.7157
	Diameter, in.	2.73
	Height, in.	5.75
At Test		
Strain rate, in./min.		0.374
Back Pressure, tsf		0.00
Cell Pressure, tsf		1.40
Fail. Stress, tsf		2.64
Ult. Stress, tsf		
σ_1 Failure, tsf		4.05
σ_3 Failure, tsf		1.40

Type of Test:
Unconsolidated Undrained

Sample Type: Shelby Tube

Description: FAT CLAY (CH) - Dark gray

Assumed Specific Gravity= 2.65

Remarks:

Figure _____

Client: Texas Parks & Wildlife Department

Project: Lake Somerville Trailway Bridge Replacement

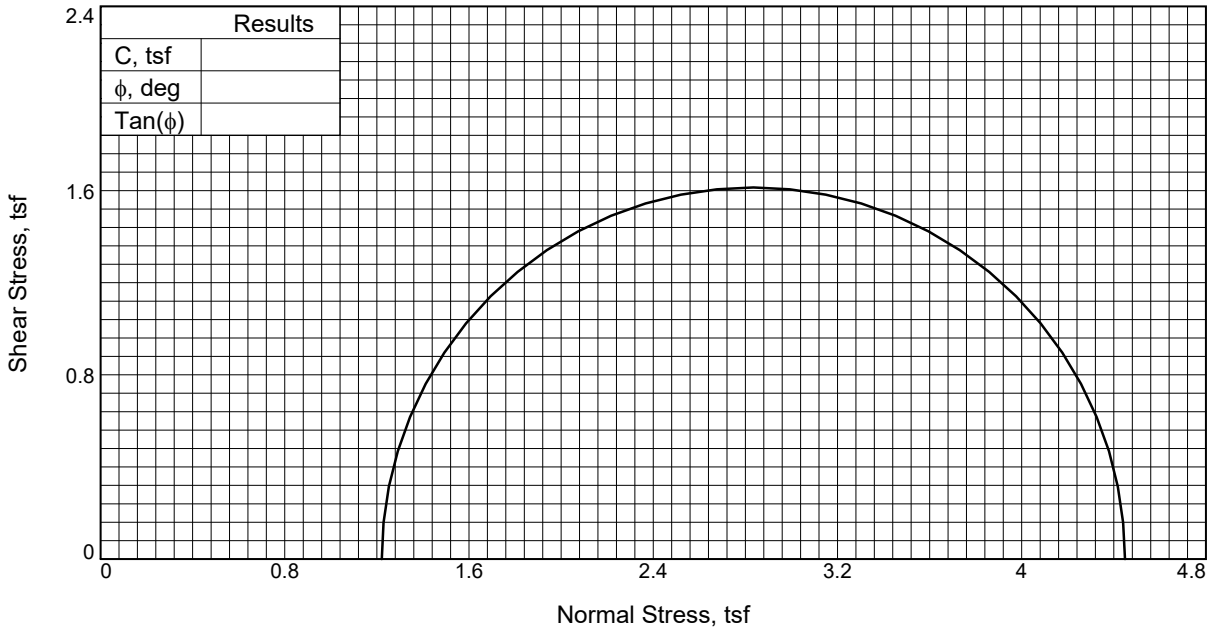
Location: B-01

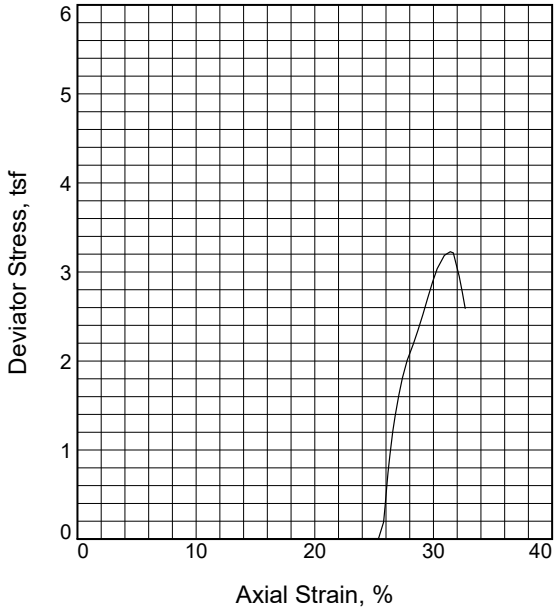
Depth: 53'-55'

Proj. No.: 23-0722 **Date Sampled:** 1/22/2024

TRIAXIAL SHEAR TEST REPORT
Riner Engineering, Inc.
Houston, Texas

Tested By: A.C. **Checked By:** R.C.





Sample No.		1
Initial	Water Content, %	30.7
	Dry Density, pcf	93.6
	Saturation, %	
	Void Ratio	0.7669
	Diameter, in.	2.77
	Height, in.	5.75
At Test		
Strain rate, in./min.		0.256
Back Pressure, tsf		0.00
Cell Pressure, tsf		1.22
Fail. Stress, tsf		3.23
Ult. Stress, tsf		
σ_1 Failure, tsf		4.45
σ_3 Failure, tsf		1.22

Type of Test:
Unconsolidated Undrained

Sample Type: Shelby Tube

Description: FAT CLAY (CH) - Dark gray

Assumed Specific Gravity= 2.65

Remarks:

Figure _____

Client: Texas Parks & Wildlife Department

Project: Lake Somerville Trailway Bridge Replacement

Location: B-02

Depth: 48'-50'

Proj. No.: 23-0722 **Date Sampled:** 1/22/2024

TRIAXIAL SHEAR TEST REPORT
Riner Engineering, Inc.
Houston, Texas

Tested By: A.C. **Checked By:** R.C.

Multi-Stage Consolidated-Undrained Triaxial Compression

Client: Riner Engineering, Inc
Project: 23-0722 Lake Somerville Trailway Bridge Replacement
Sample: B-02 (6'-8')

TRI Log #: 24-000292-01
Test Method: ASTM D4767 Mod

Specimens				
Identification	1	2	3	4
Depth/Elev. (ft)	-	-	-	-
Eff. Consol. Stress (psi)	5.0	10.0	15.0	-
Initial Specimen Properties				
Avg. Diameter (in)	1.44	1.45	1.46	-
Avg. Height (in)	3.39	3.37	3.30	-
Avg. Water Content (%)	14.9	-	-	-
Bulk Density (pcf)	130.9	-	-	-
Dry Density (pcf)	113.9	-	-	-
Specific Gravity (Assumed)	2.75			
Saturation (%)	80.9	-	-	-
Void Ratio, n	0.51	0.51	0.51	-
B-Value, End of Saturation	0.97	-	-	-

Test Setup	
Specimen Condition	Undisturbed / Intact
Specimen Preparation	Trimmed
Mounting Method	Wet
Consolidation	Isotropic

Post-Consolidation / Pre-Shear				
Void Ratio	0.51	0.51	0.51	-

Shear / Post-Shear				
Rate of Strain (%/hr)	1.00	1.00	1.00	-
Avg. Water Content (%)	-	-	16.2	-

At Failure								
Failure Criterion: Peak Principal Stress	Difference, $(\sigma_1'-\sigma_3')_{max}$				Ratio, $(\sigma_1'/\sigma_3')_{max}$			
Axial Strain at Failure (%), $\varepsilon_{a,f}$	1.0	2.5	9.5	-	0.8	1.0	0.8	-
Minor Effective Stress (psi), $\sigma_3'_f$	3.5	8.7	20.5	-	3.3	6.7	10.7	-
Principal Stress Difference (psi), $(\sigma_1-\sigma_3)_f$	17.5	28.8	50.4	-	16.7	23.6	34.4	-
Pore Water Pressure, Δu_f (psi)	1.5	1.3	-5.6	-	1.8	3.3	4.3	-
Major Effective Stress (psi), $\sigma_1'_f$	21.1	37.5	71.0	-	20.0	30.3	45.0	-
Secant Friction Angle (degrees)	45.5	38.6	33.4	-	45.9	39.6	38.1	-
Effective Friction Angle (degrees)	29.3				33.1			
Effective Cohesion (psi)	3.3				2.3			

Note: Multi-stage testing was performed for this sample. The first two stages were terminated in accordance with stress path tangency and/or peak principal stress ratio. The presented M-C parameters are based on a linear regression in modified stress space, across all assigned effective consolidation stresses. This fit does not purported to capture typical curvature of envelopes that may, in particular, be observed across broader range in effective stresses. Please note that the stresses associated with peak principal stress ratio are presented in tabular form on the first page of the report. There are alternate interpretations to this failure criterion including but not limited to peak principal stress difference and strain compatibility.

Jeffrey A. Kuhn , Ph.D., P.E., 3/1/2024
Analysis & Quality Review/Date

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested. TRI neither accepts responsibility for nor makes claim as to the final use and purpose of the material. TRI observes and maintains client confidentiality. TRI limits reproduction of this report, except in full, without prior approval of TRI.

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9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

Multi-Stage Consolidated-Undrained Triaxial Compression

Client: Riner Engineering, Inc
Project: 23-0722 Lake Somerville Trailway Bridge Replacement
Sample: B-02 (6'-8')

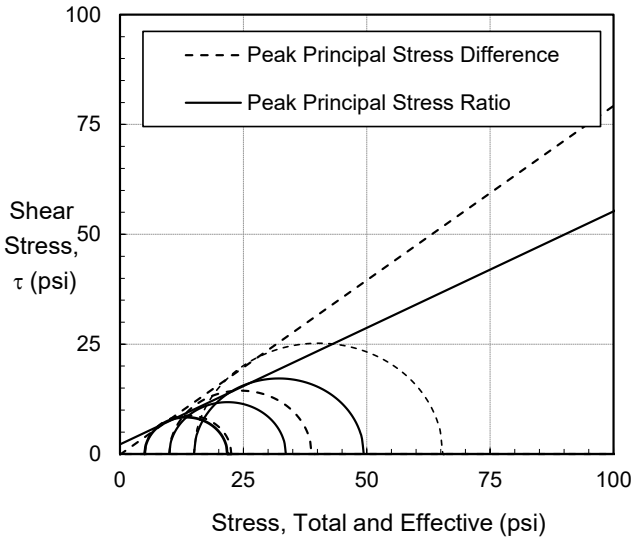
TRI Log #: 24-000292-01
Test Method: ASTM D4767 Mod

R / "Total Stress" Envelope			
Failure Criterion: Peak Principal Stress		Difference, $(\sigma_1'-\sigma_3')_{max}$	Ratio, $(\sigma_1'/\sigma_3')_{max}$
Friction Angle (deg)	ϕ_R	38.4	27.9
Cohesion (psi)	c_R	-0.1	2.2

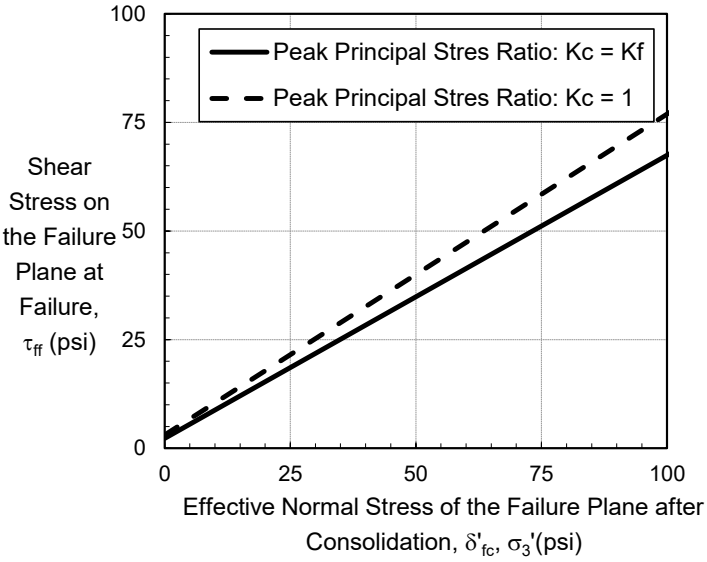
Kc = Kf Envelope, Effective Stress Envelope (Duncan et al. 1990)			
Failure Criterion: Peak Principal Stress		Difference, $(\sigma_1'-\sigma_3')_{max}$	Ratio, $(\sigma_1'/\sigma_3')_{max}$
Effective Friction Angle (deg)	ϕ'	29.3	33.1
Effective Cohesion (psi)	c'	3.3	2.3

Kc = 1 (τ_{ff} vs σ'_{fc}) Envelope, Total Stress Envelope (Duncan et al. 1990)			
Failure Criterion: Peak Principal Stress		Difference, $(\sigma_1'-\sigma_3')_{max}$	Ratio, $(\sigma_1'/\sigma_3')_{max}$
Friction Angle (deg)	$d_{Kc=1}$	55.1	36.5
Cohesion (psi)	$\psi_{Kc=1}$	-0.3	3.0

R / "Total Stress" Envelope



Three-Stage Rapid Drawdown Envelopes



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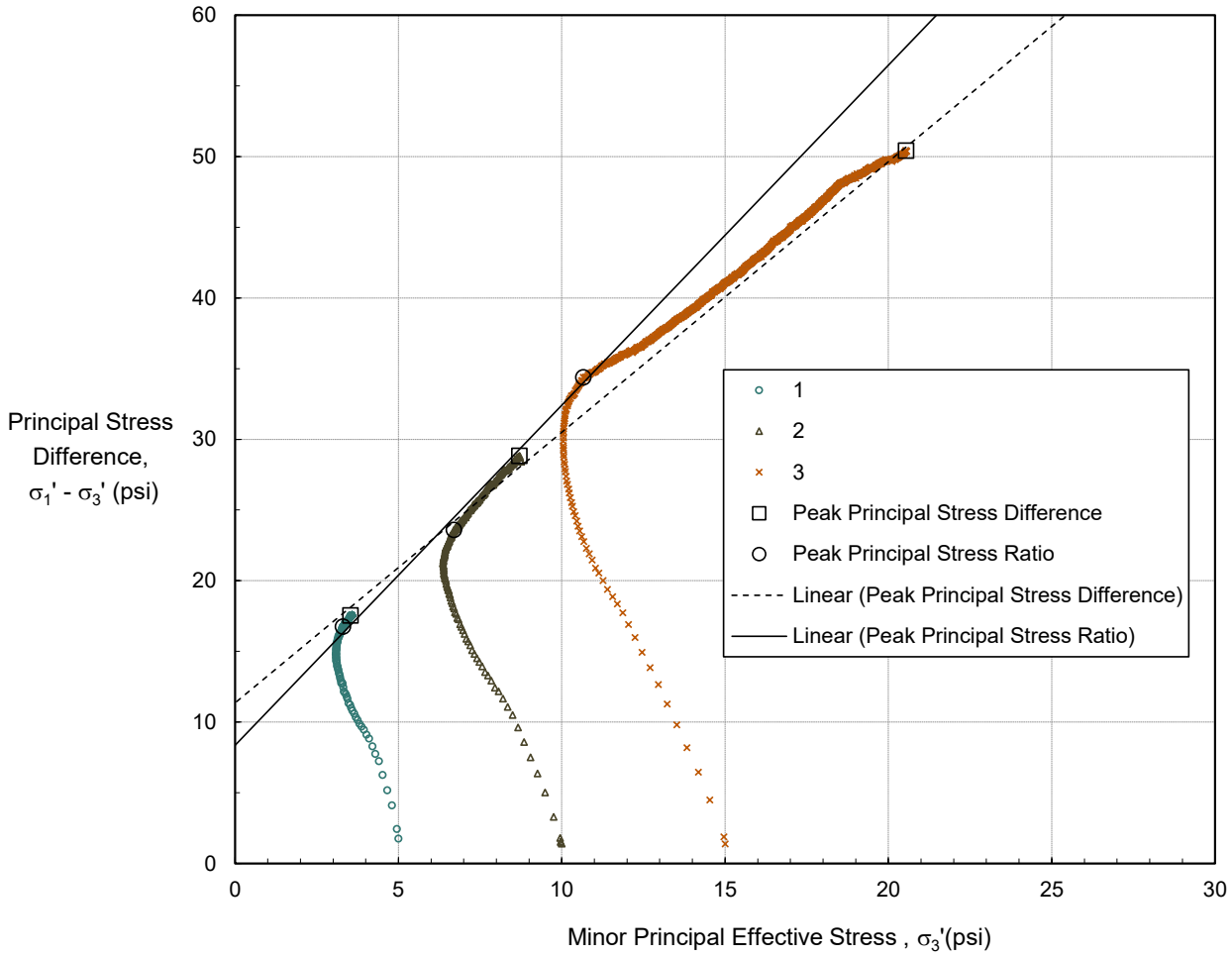
Multi-Stage Consolidated-Undrained Triaxial Compression

Client: Riner Engineering, Inc
Project: 23-0722 Lake Somerville Trailway Bridge Replacement
Sample: B-02 (6'-8')

TRI Log #: 24-000292-01
Test Method: ASTM D4767 Mod

Modified Mohr-Coulomb



Failure Criterion: Peak Principal Stress	Difference, $(\sigma_1'-\sigma_3')_{max}$	Ratio, $(\sigma_1'/\sigma_3')_{max}$
Effective Friction Angle (deg)	29.3	33.1
Effective Cohesion (psi)	3.3	2.3

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested. TRI neither accepts responsibility for nor makes claim as to the final use and purpose of the material. TRI observes and maintains client confidentiality. TRI limits reproduction of this report, except in full, without prior approval of TRI.

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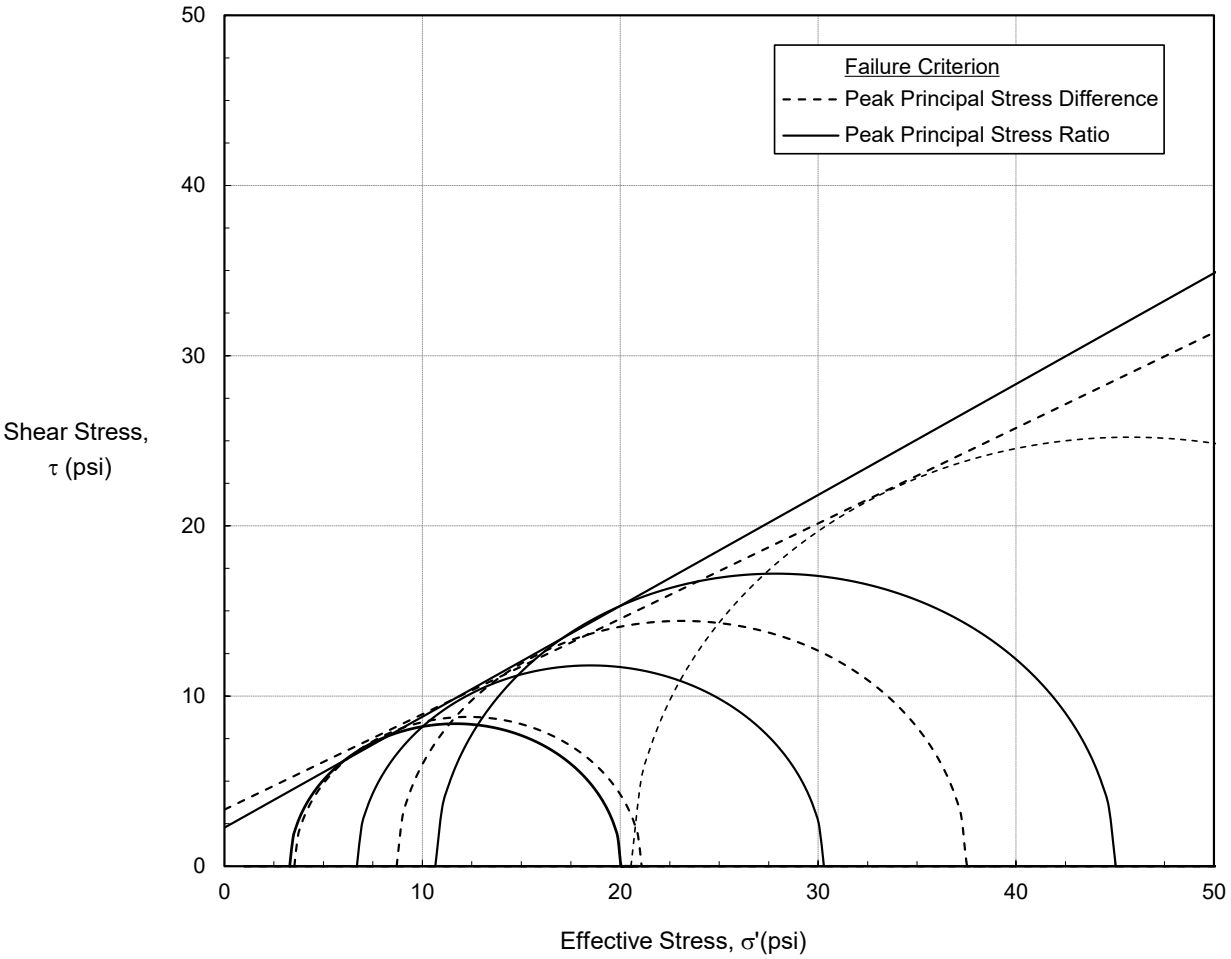
Multi-Stage Consolidated-Undrained Triaxial Compression

Client: Riner Engineering, Inc
Project: 23-0722 Lake Somerville Trailway Bridge Replacement
Sample: B-02 (6'-8')

TRI Log #: 24-000292-01
Test Method: ASTM D4767 Mod

Mohr-Coulomb



Failure Criterion: Peak Principal Stress	Difference, $(\sigma_1'-\sigma_3')_{max}$	Ratio, $(\sigma_1'/\sigma_3')_{max}$
Effective Friction Angle (deg)	29.3	33.1
Effective Cohesion (psi)	3.3	2.3

The testing herein is based upon accepted industry practice as well as the test method listed. Test results reported herein do not apply to samples other than those tested. TRI neither accepts responsibility for nor makes claim as to the final use and purpose of the material. TRI observes and maintains client confidentiality. TRI limits reproduction of this report, except in full, without prior approval of TRI.

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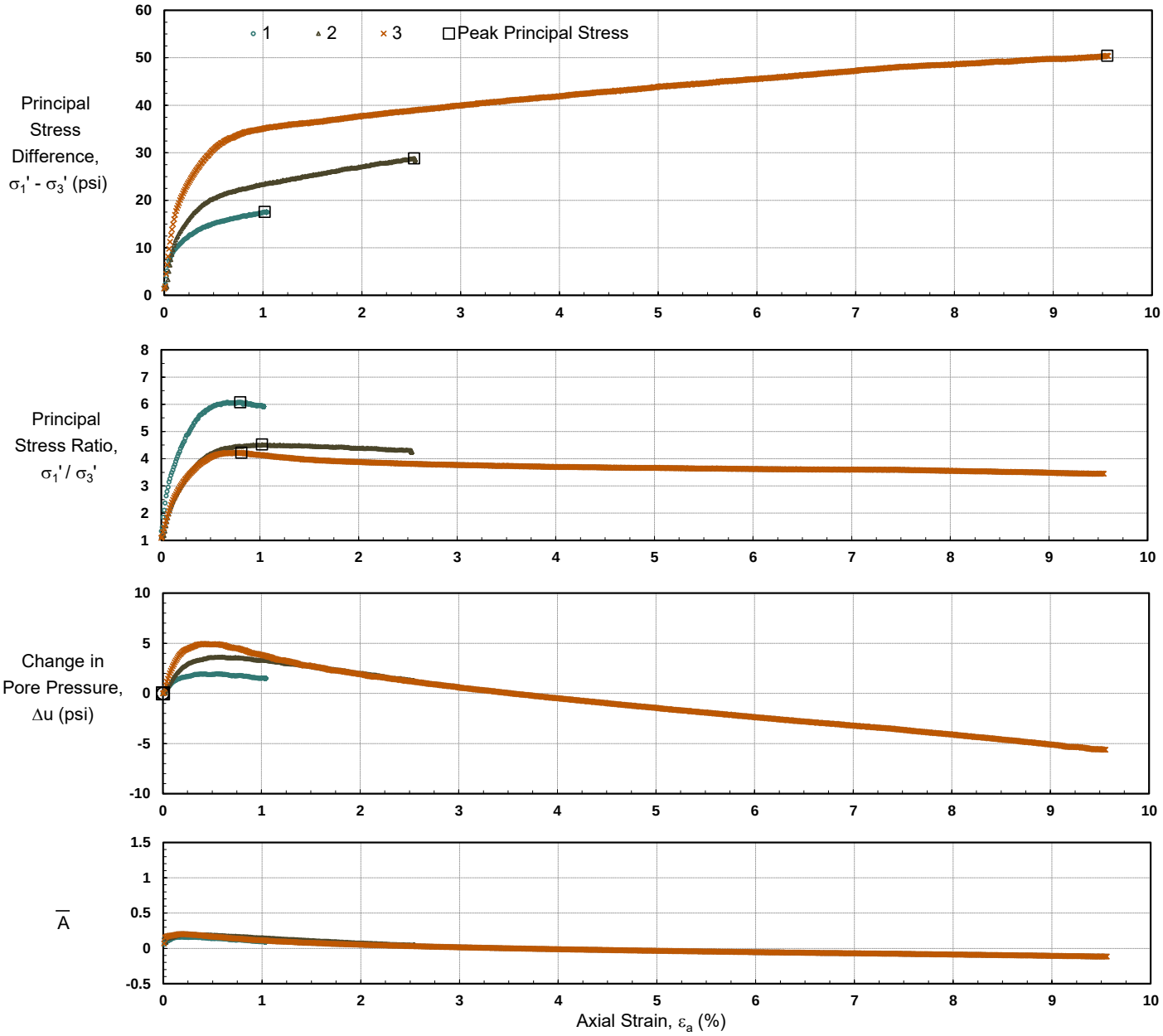
Multi-Stage Consolidated-Undrained Triaxial Compression

Client: Riner Engineering, Inc
Project: 23-0722 Lake Somerville Trailway Bridge Replacement
Sample: B-02 (6'-8')

TRI Log #: 24-000292-01
Test Method: ASTM D4767 Mod



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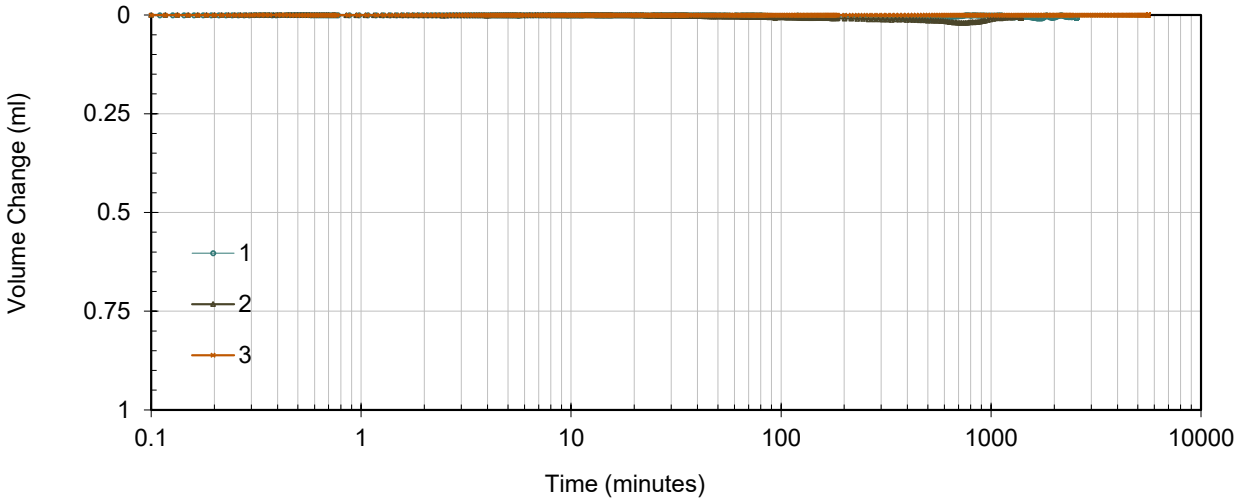
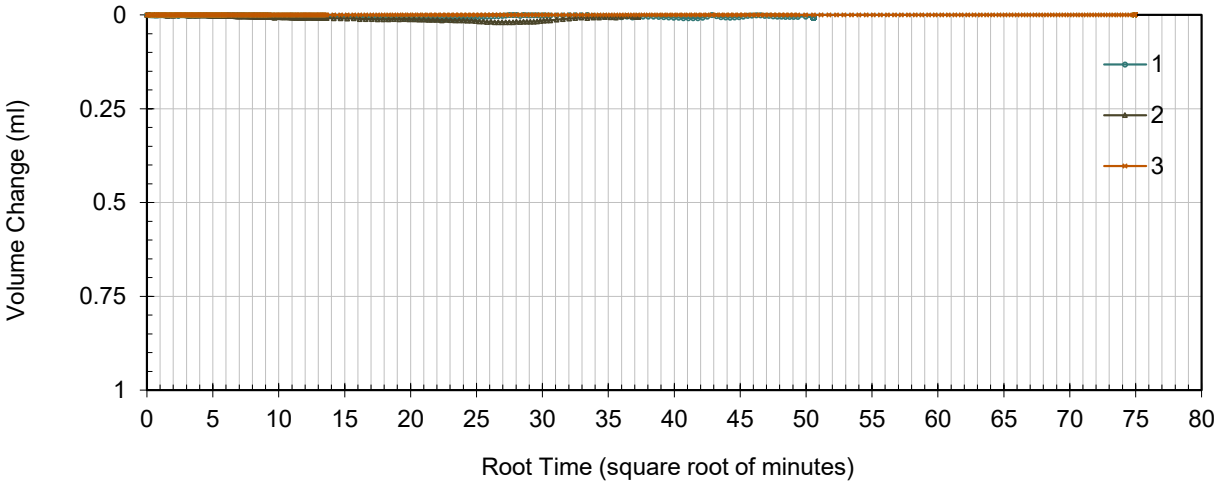
Multi-Stage Consolidated-Undrained Triaxial Compression

Client: Riner Engineering, Inc
Project: 23-0722 Lake Somerville Trailway Bridge Replacement
Sample: B-02 (6'-8')

TRI Log #: 24-000292-01
Test Method: ASTM D4767 Mod

Consolidation





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TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

Multi-Stage Consolidated-Undrained Triaxial Compression

Client: Riner Engineering, Inc
Project: 23-0722 Lake Somerville Trailway Bridge Replacement
Sample: B-01 (28'-30')

TRI Log #: 24-000292-02
Test Method: ASTM D4767 Mod

Specimens				
Identification	1	2	3	4
Depth/Elev. (ft)	-	-	-	-
Eff. Consol. Stress (psi)	5.0	10.0	15.0	-
Initial Specimen Properties				
Avg. Diameter (in)	1.43	1.43	1.42	-
Avg. Height (in)	2.94	2.88	2.85	-
Avg. Water Content (%)	34.1	-	-	-
Bulk Density (pcf)	112.1	-	-	-
Dry Density (pcf)	83.6	-	-	-
Specific Gravity (Assumed)	2.75			
Saturation (%)	89.1	-	-	-
Void Ratio, n	1.05	1.00	0.96	-
B-Value, End of Saturation	0.98	-	-	-

Test Setup	
Specimen Condition	Undisturbed / Intact
Specimen Preparation	Trimmed
Mounting Method	Wet
Consolidation	Isotropic

Post-Consolidation / Pre-Shear				
Void Ratio	1.00	0.96	0.92	-

Shear / Post-Shear				
Rate of Strain (%/hr)	1.00	1.00	1.00	-
Avg. Water Content (%)	-	-	40.3	-

At Failure								
Failure Criterion: Peak Principal Stress	Difference, $(\sigma_1'-\sigma_3')_{max}$				Ratio, $(\sigma_1'/\sigma_3')_{max}$			
Axial Strain at Failure (%), $\varepsilon_{a,f}$	1.5	1.4	1.7	-	0.9	1.4	1.4	-
Minor Effective Stress (psi), $\sigma_3'_f$	1.8	3.4	5.1	-	1.7	3.4	5.1	-
Principal Stress Difference (psi), $(\sigma_1-\sigma_3)_f$	12.9	17.5	21.4	-	12.2	17.5	21.3	-
Pore Water Pressure, Δu_f (psi)	3.3	6.6	9.9	-	3.4	6.6	10.0	-
Major Effective Stress (psi), $\sigma_1'_f$	14.7	20.9	26.6	-	13.9	20.9	26.4	-
Secant Friction Angle (degrees)	51.4	46.3	42.5	-	51.7	46.3	42.7	-
Effective Friction Angle (degrees)	34.0				35.1			
Effective Cohesion (psi)	2.3				2.1			

Note: Multi-stage testing was performed for this sample. The first two stages were terminated in accordance with stress path tangency and/or peak principal stress ratio. The presented M-C parameters are based on a linear regression in modified stress space, across all assigned effective consolidation stresses. This fit does not purported to capture typical curvature of envelopes that may, in particular, be observed across broader range in effective stresses. Please note that the stresses associated with peak principal stress ratio are presented in tabular form on the first page of the report. There are alternate interpretations to this failure criterion including but not limited to peak principal stress difference and strain compatibility.

Jeffrey A. Kuhn , Ph.D., P.E., 3/1/2024
Analysis & Quality Review/Date

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Multi-Stage Consolidated-Undrained Triaxial Compression

Client: Riner Engineering, Inc
Project: 23-0722 Lake Somerville Trailway Bridge Replacement
Sample: B-01 (28'-30')

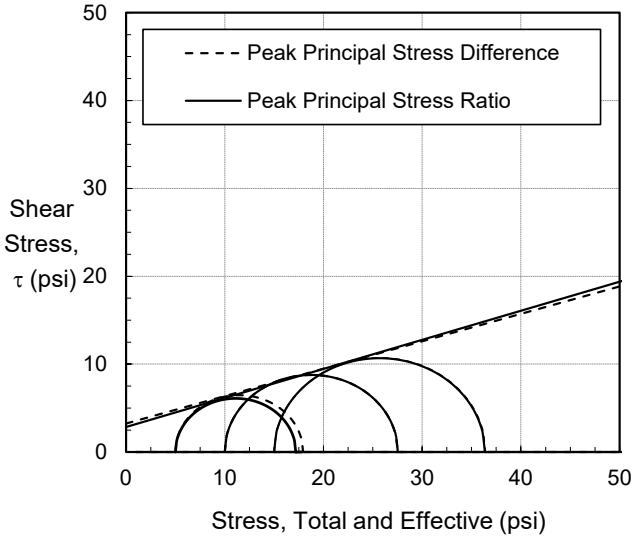
TRI Log #: 24-000292-02
Test Method: ASTM D4767 Mod

R / "Total Stress" Envelope			
Failure Criterion: Peak Principal Stress		Difference, $(\sigma_1'-\sigma_3')_{max}$	Ratio, $(\sigma_1'/\sigma_3')_{max}$
Friction Angle (deg)	ϕ_R	17.3	18.3
Cohesion (psi)	c_R	3.2	2.8

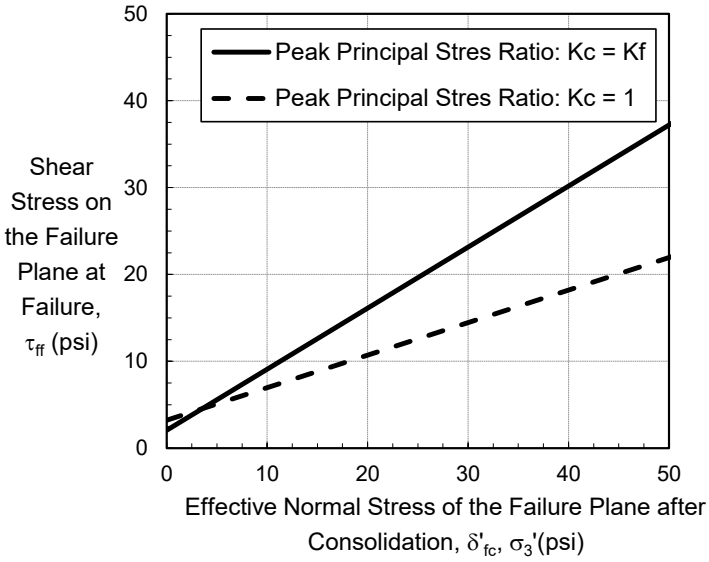
Kc = Kf Envelope, Effective Stress Envelope (Duncan et al. 1990)			
Failure Criterion: Peak Principal Stress		Difference, $(\sigma_1'-\sigma_3')_{max}$	Ratio, $(\sigma_1'/\sigma_3')_{max}$
Effective Friction Angle (deg)	ϕ'	34.0	35.1
Effective Cohesion (psi)	c'	2.3	2.1

Kc = 1 (τ_{ff} vs σ'_{fc}) Envelope, Total Stress Envelope (Duncan et al. 1990)			
Failure Criterion: Peak Principal Stress		Difference, $(\sigma_1'-\sigma_3')_{max}$	Ratio, $(\sigma_1'/\sigma_3')_{max}$
Friction Angle (deg)	$d_{Kc=1}$	19.4	20.5
Cohesion (psi)	$\psi_{Kc=1}$	3.7	3.2

R / "Total Stress" Envelope



Three-Stage Rapid Drawdown Envelopes



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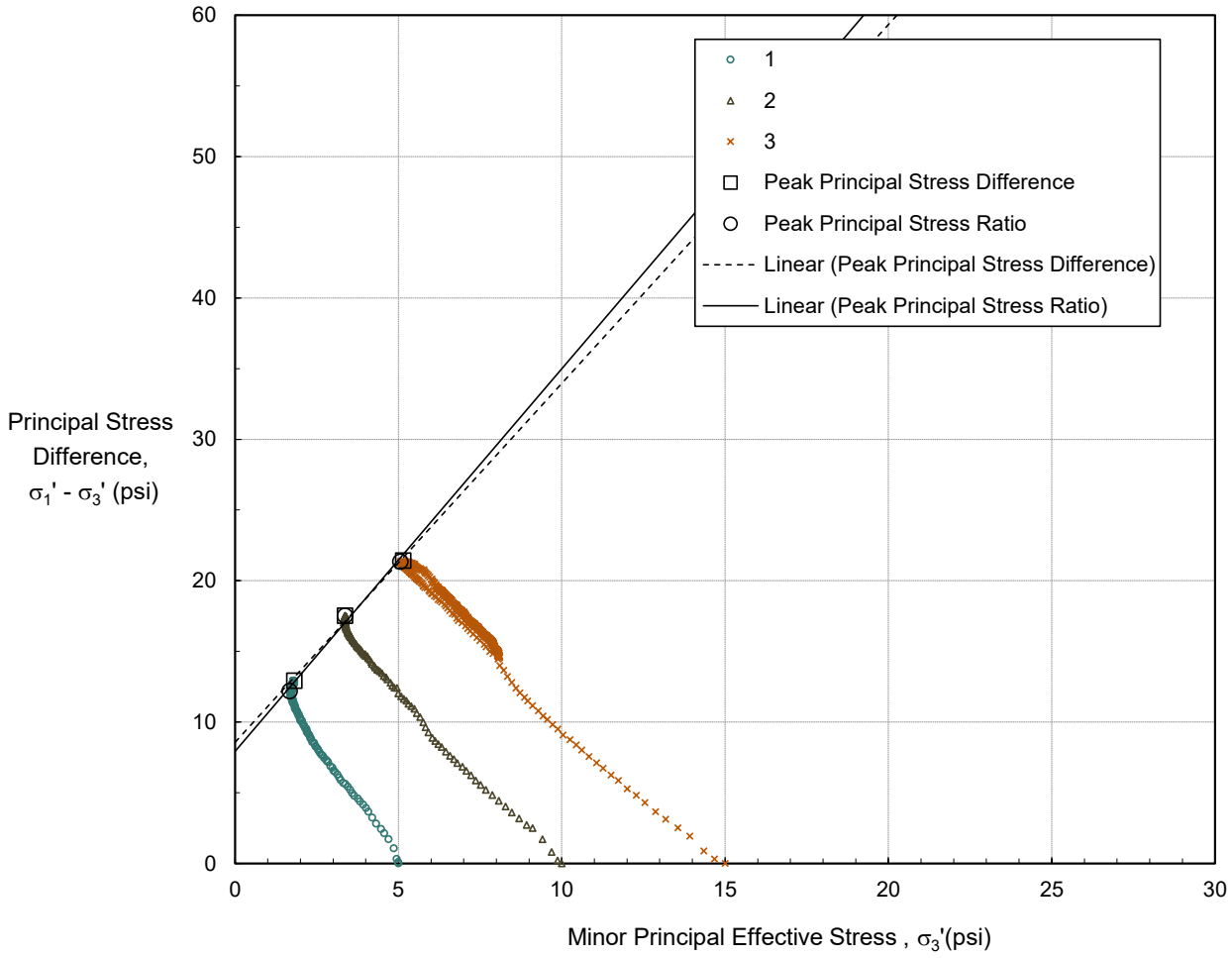
TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

Multi-Stage Consolidated-Undrained Triaxial Compression

Client: Riner Engineering, Inc
Project: 23-0722 Lake Somerville Trailway Bridge Replacement
Sample: B-01 (28'-30')

TRI Log #: 24-000292-02
Test Method: ASTM D4767 Mod

Modified Mohr-Coulomb



Failure Criterion: Peak Principal Stress	Difference, $(\sigma_1'-\sigma_3')_{max}$	Ratio, $(\sigma_1'/\sigma_3')_{max}$
Effective Friction Angle (deg)	34.0	35.1
Effective Cohesion (psi)	2.3	2.1

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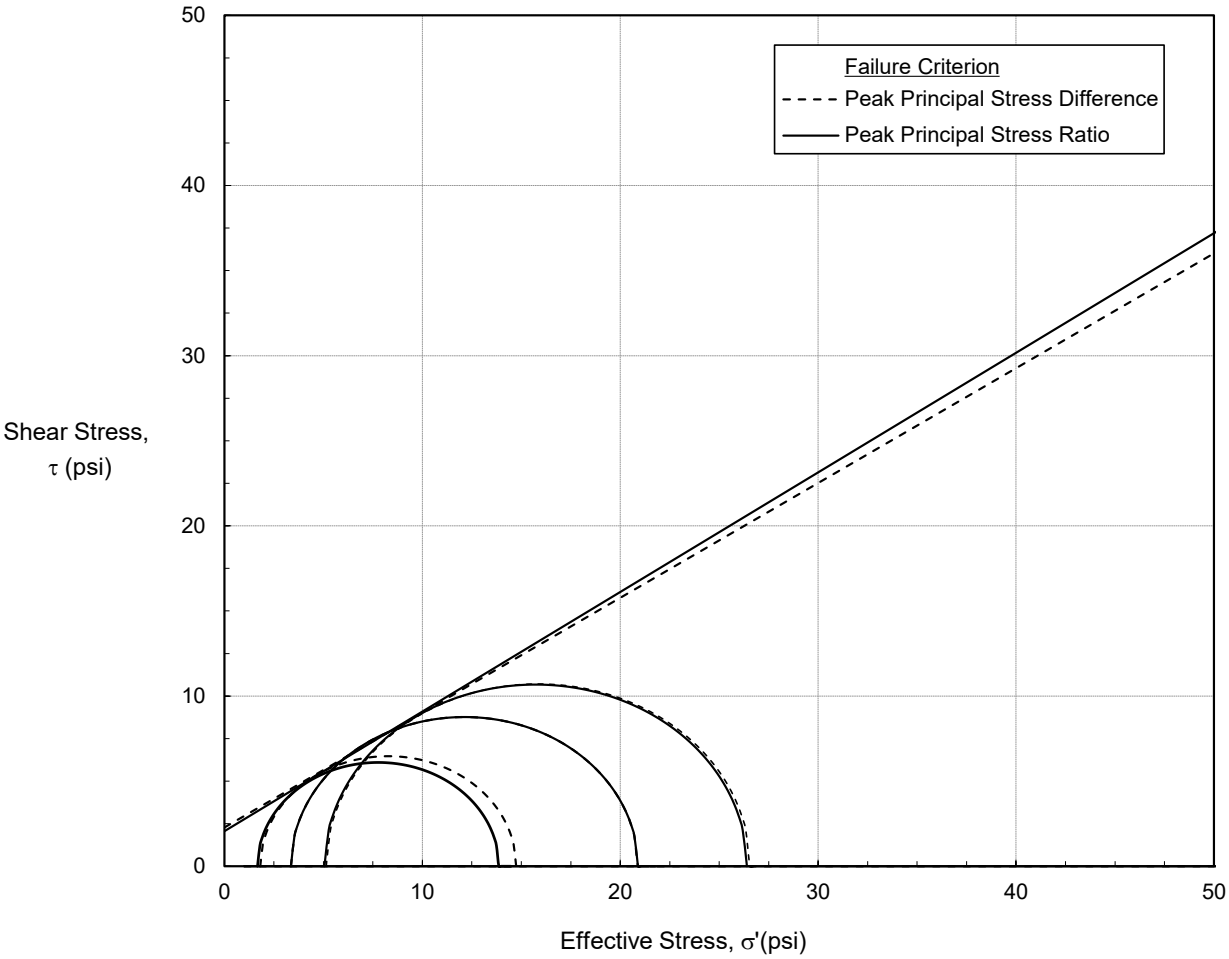
Client: Riner Engineering, Inc
Project: 23-0722 Lake Somerville Trailway Bridge Replacement
Sample: B-01 (28'-30')

TRI Log #: 24-000292-02
Test Method: ASTM D4767 Mod

Mohr-Coulomb



Failure Criterion: Peak Principal Stress	Difference, $(\sigma_1'-\sigma_3')_{max}$	Ratio, $(\sigma_1'/\sigma_3')_{max}$
Effective Friction Angle (deg)	34.0	35.1
Effective Cohesion (psi)	2.3	2.1

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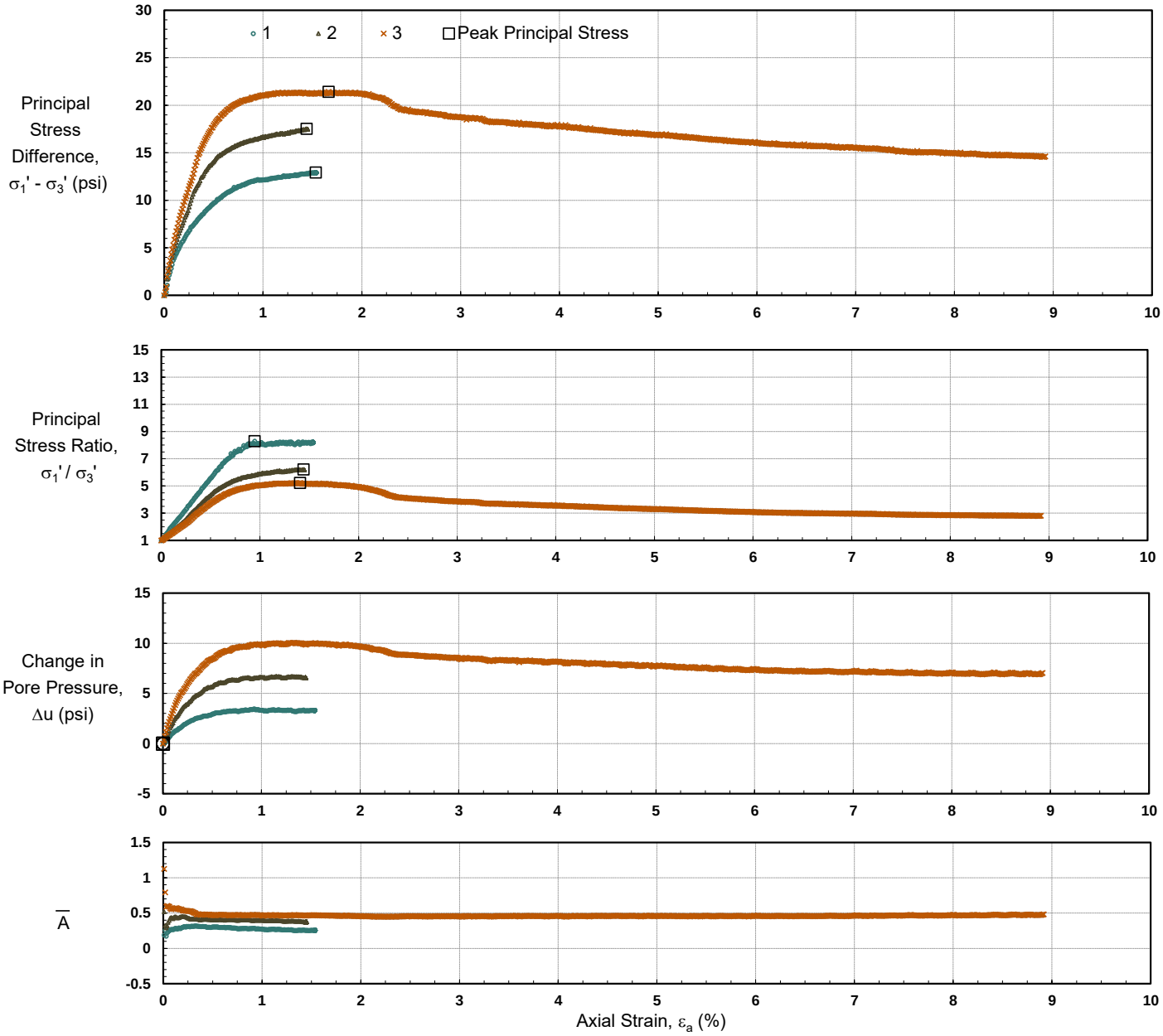
Client: Riner Engineering, Inc
Project: 23-0722 Lake Somerville Trailway Bridge Replacement
Sample: B-01 (28'-30')

TRI Log #: 24-000292-02
Test Method: ASTM D4767 Mod



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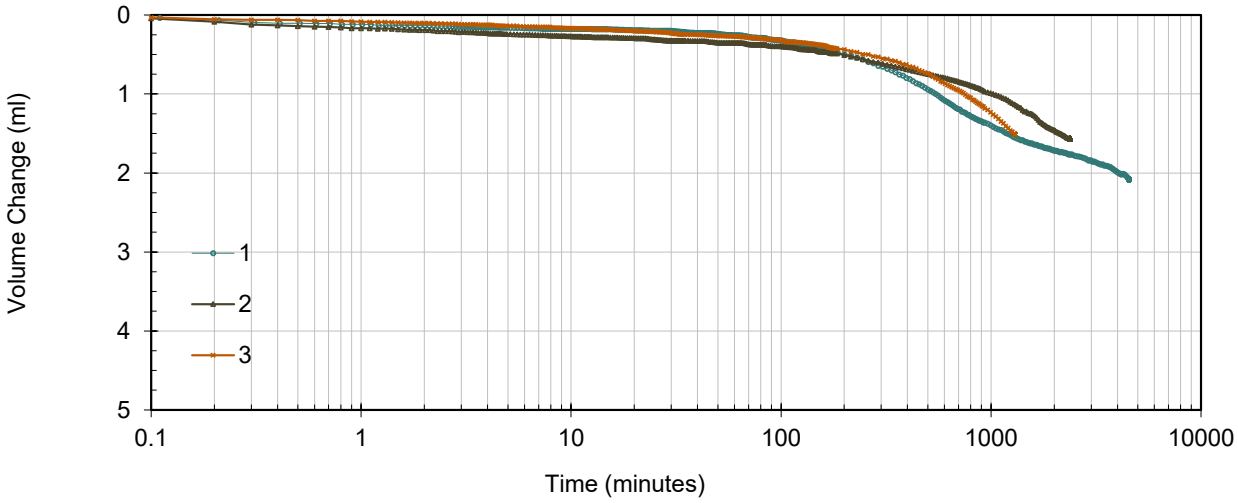
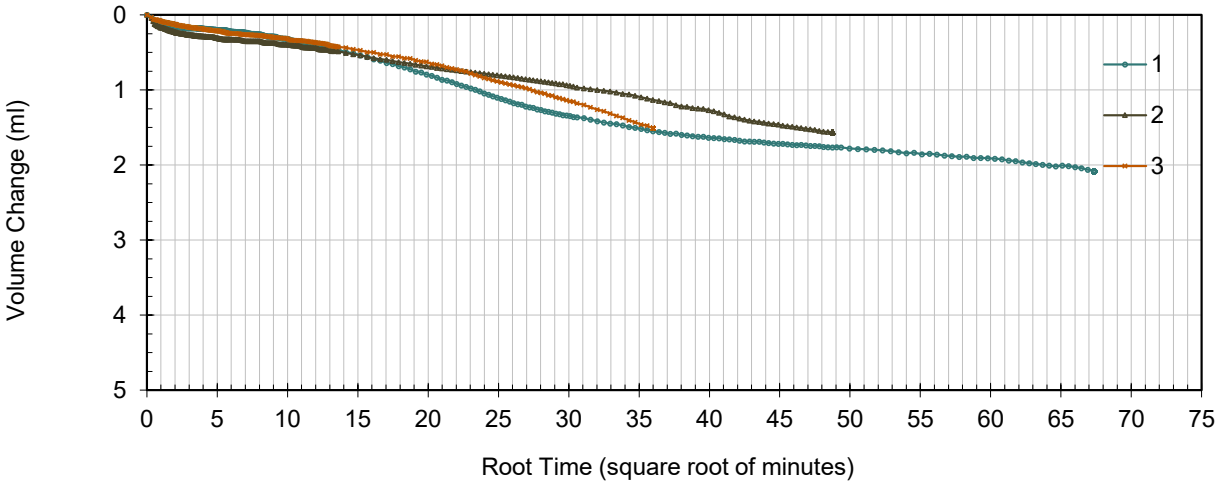
Multi-Stage Consolidated-Undrained Triaxial Compression

Client: Riner Engineering, Inc
Project: 23-0722 Lake Somerville Trailway Bridge Replacement
Sample: B-01 (28'-30')

TRI Log #: 24-000292-02
Test Method: ASTM D4767 Mod

Consolidation





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TRI ENVIRONMENTAL, INC.
9063 BEE CAVES RD. – AUSTIN, TX 78733 – USA | PH: 800.880.TEST OR 512.263.2101

Riner Engineering Inc.

Soil Laboratory Sulfate Content (Tex-145-E)

Project Name: Lake Somerville Trailway Bridge Replacement **Project No.:** 23-0722 **Date:** 1/23/2024

Boring No. B-01 **Sample No.** 1 **Sample Depth (ft.)** 6-8

Dilution Ratio Used	1:20	Dilution Ratio Used	1:20	Dilution Ratio Used	1:20
Average Reading	64.0	Average Reading	61.0	Average Reading	58.0
Sulfate Content	1280	Sulfate Content	1220	Sulfate Content	1160

Average Sulfate Content: 1220 ppm

Boring No. B-02 **Sample No.** 1 **Sample Depth (ft.)** 28-30

Dilution Ratio Used	1:20	Dilution Ratio Used	1:40	Dilution Ratio Used	1:20
Average Reading	59.0	Average Reading	65.0	Average Reading	63.0
Sulfate Content	1180	Sulfate Content	2600	Sulfate Content	1260

Average Sulfate Content: 1680 ppm

Boring No. B-03 **Sample No.** 1 **Sample Depth (ft.)** 6-8

Dilution Ratio Used	1:20	Dilution Ratio Used	1:40	Dilution Ratio Used	1:20
Average Reading	93.0	Average Reading	92.0	Average Reading	89.0
Sulfate Content	1860	Sulfate Content	3680	Sulfate Content	1780

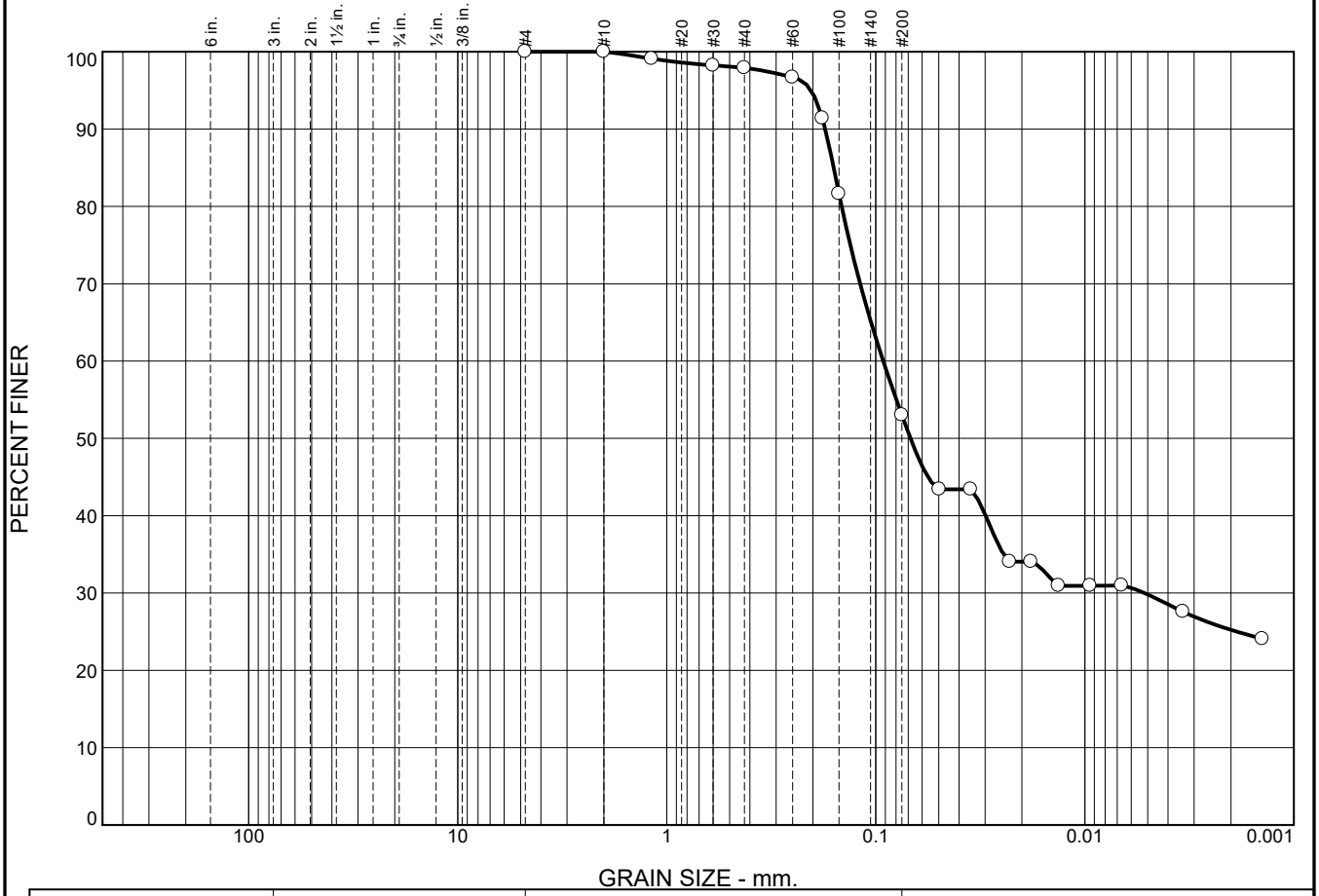
Average Sulfate Content: 2440 ppm

Boring No. B-04 **Sample No.** 1 **Sample Depth (ft.)** 13-15

Dilution Ratio Used	1:20	Dilution Ratio Used	1:20	Dilution Ratio Used	1:20
Average Reading	53.0	Average Reading	48.0	Average Reading	50.0
Sulfate Content	1060	Sulfate Content	960	Sulfate Content	1000

Average Sulfate Content: 1007 ppm

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.0	0.0	2.1	44.9	27.8	25.2

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_C	C_u
○			0.1590	0.0922	0.0683	0.0052				

Material Description	USCS	AASHTO
○		

Project No. 23-0722 **Client:** Texas Parks & Wildlife Department

Project: Lake Somerville Trailway Bridge Replacement

○ **Location:** B-01 **Depth:** 4'-5'

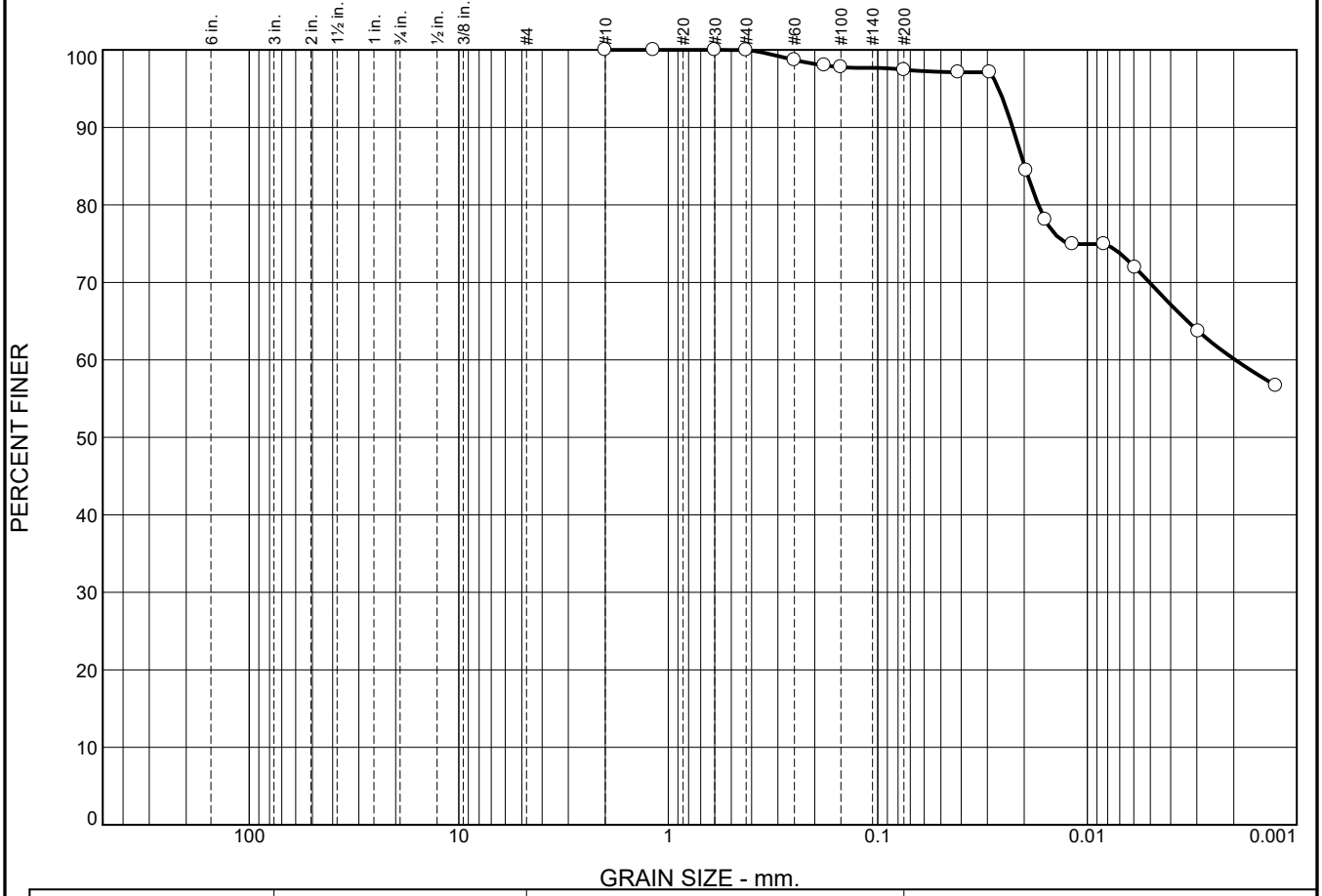
Remarks:

Riner Engineering, Inc.

Houston, Texas

Figure

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.0	0.0	0.0	2.6	37.3	60.1

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_C	C_u
○			0.0199	0.0020						

	Material Description	USCS	AASHTO
○			

Project No. 23-0722 **Client:** Texas Parks & Wildlife Department

Project: Lake Somerville Trailway Bridge Replacement

○ **Location:** B-02 **Depth:** 28'-30'

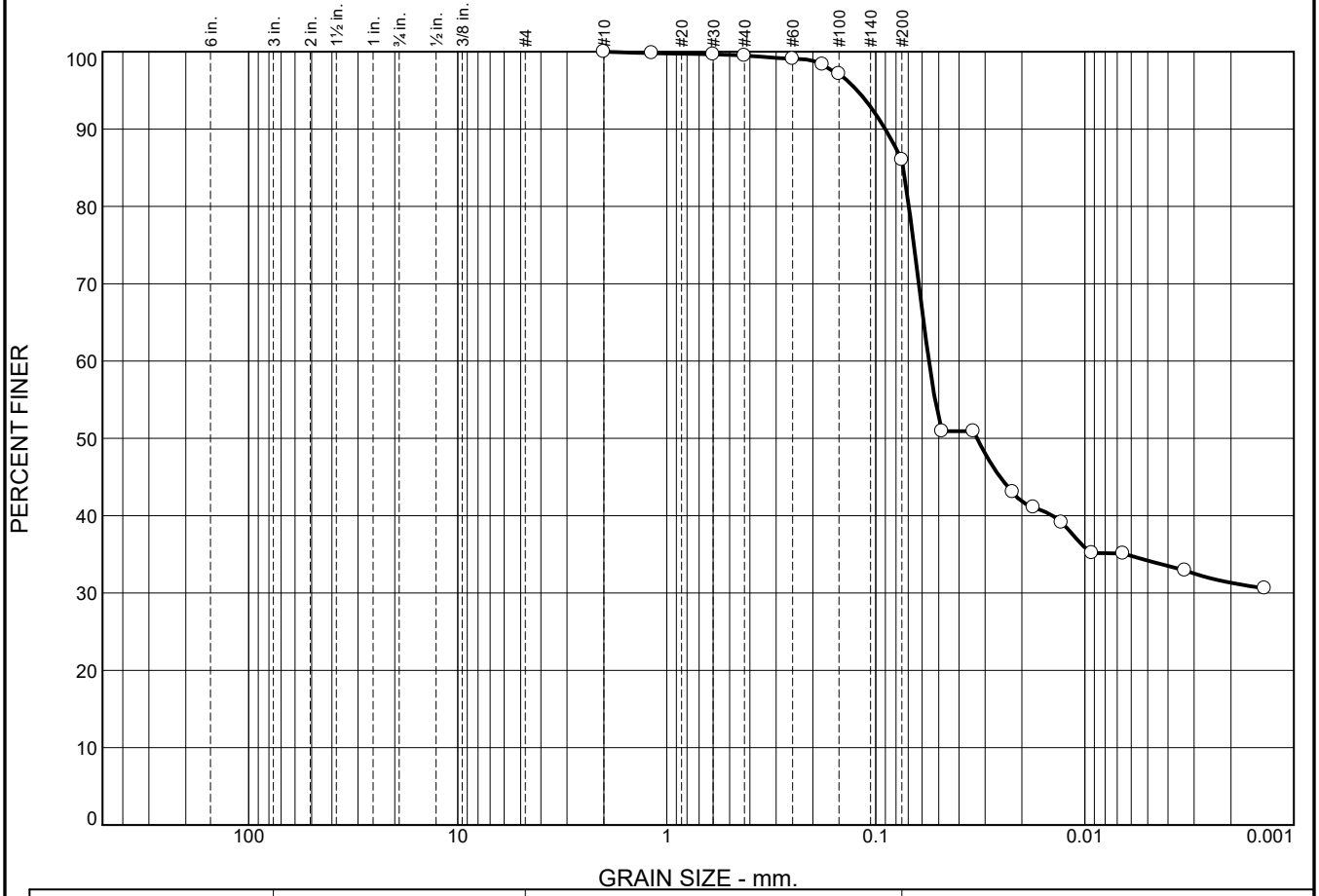
Remarks:

Riner Engineering, Inc.

Houston, Texas

Figure

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.0	0.0	0.5	13.5	54.7	31.3

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_C	C_u
○			0.0739	0.0557	0.0328					

Material Description	USCS	AASHTO
○		

Project No. 23-0722 **Client:** Texas Parks & Wildlife Department

Project: Lake Somerville Trailway Bridge Replacement

○ **Location:** B-03 **Depth:** 4'-5'

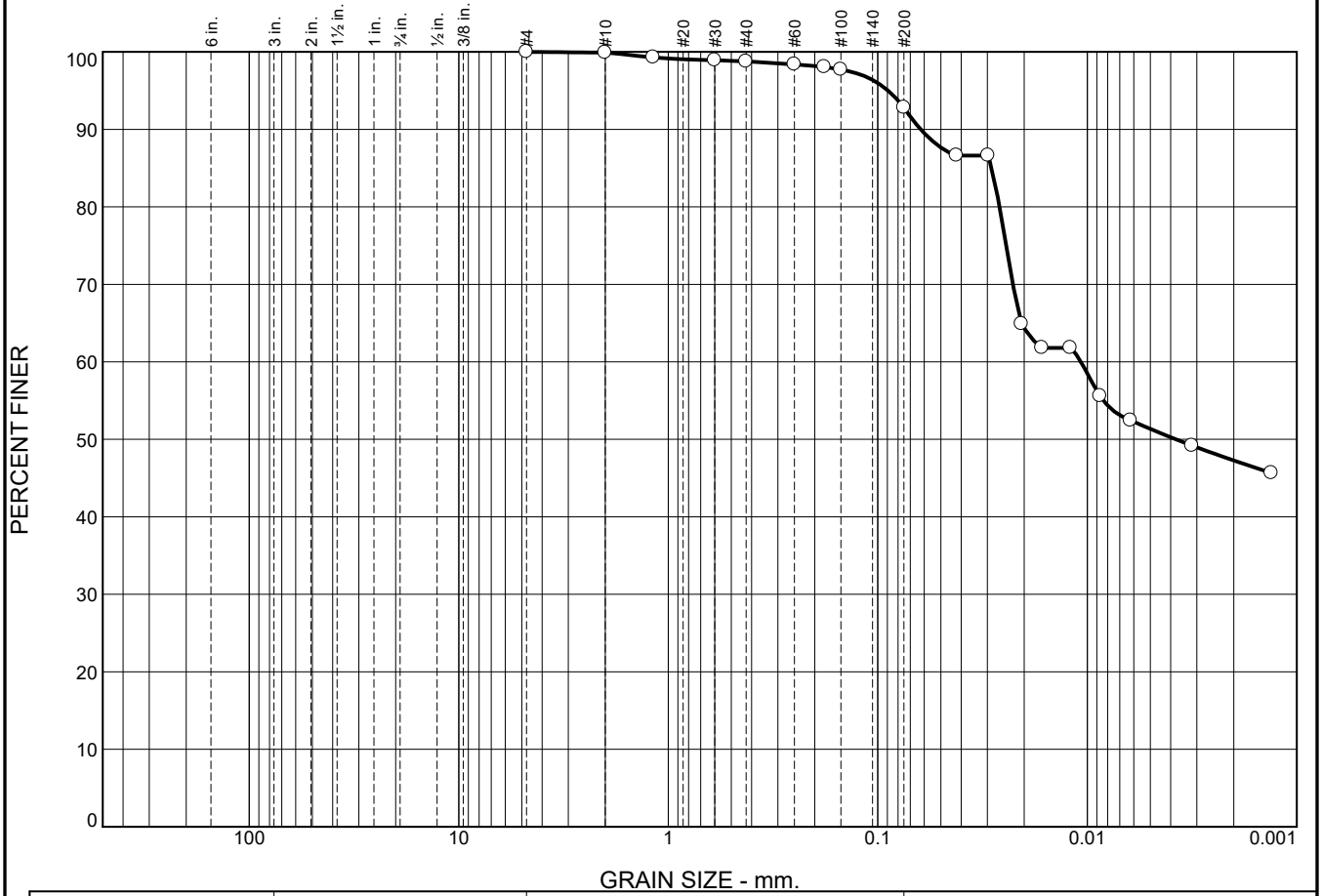
Remarks:

Riner Engineering, Inc.

Houston, Texas

Figure

Particle Size Distribution Report



	% +3"	% Gravel		% Sand			% Fines	
		Coarse	Fine	Coarse	Medium	Fine	Silt	Clay
○	0.0	0.0	0.0	0.1	1.1	6.0	45.5	47.3

	LL	PL	D_{85}	D_{60}	D_{50}	D_{30}	D_{15}	D_{10}	C_C	C_u
○			0.0286	0.0107	0.0038					

	Material Description	USCS	AASHTO
○			

Project No. 23-0722 **Client:** Texas Parks & Wildlife Department

Project: Lake Somerville Trailway Bridge Replacement

○ **Location:** B-04 **Depth:** 4'-5'

Remarks:

Riner Engineering, Inc.

Houston, Texas

Figure

Client Sample Results

Client: Riner Engineering
Project/Site: Tiara Diamond

Job ID: 860-66084-1
SDG: 21-0722

Client Sample ID: B-03
Lab Sample ID: 860-66084-1
Date Collected: 01/15/24 00:00
Matrix: Solid
Date Received: 01/23/24 10:22

Method: SW846 9056A - Anions, Ion Chromatography

Analyte	Result	Qualifier	RL		Unit	D	Prepared	Analyzed	Dil Fac
Chloride	509		10.0		mg/Kg		01/25/24 22:47	01/26/24 06:09	1

Client Sample ID: B-02
Lab Sample ID: 860-66084-2
Date Collected: 01/15/24 00:00
Matrix: Solid
Date Received: 01/23/24 10:22

Method: SW846 9056A - Anions, Ion Chromatography

Analyte	Result	Qualifier	RL		Unit	D	Prepared	Analyzed	Dil Fac
Chloride	87.2		9.98		mg/Kg		01/25/24 22:47	01/26/24 06:39	1

Client Sample ID: B-04
Lab Sample ID: 860-66084-3
Date Collected: 01/15/24 00:00
Matrix: Solid
Date Received: 01/23/24 10:22

Method: SW846 9056A - Anions, Ion Chromatography

Analyte	Result	Qualifier	RL		Unit	D	Prepared	Analyzed	Dil Fac
Chloride	252		9.96		mg/Kg		01/25/24 22:47	01/26/24 06:49	1

Client Sample ID: B-01
Lab Sample ID: 860-66084-4
Date Collected: 01/15/24 00:00
Matrix: Solid
Date Received: 01/23/24 10:22

Method: SW846 9056A - Anions, Ion Chromatography

Analyte	Result	Qualifier	RL		Unit	D	Prepared	Analyzed	Dil Fac
Chloride	101		9.92		mg/Kg		01/25/24 22:47	01/26/24 06:59	1

Appendix D - Site Photographs

SITE PHOTOGRAPHS

Boring B-01 Facing East

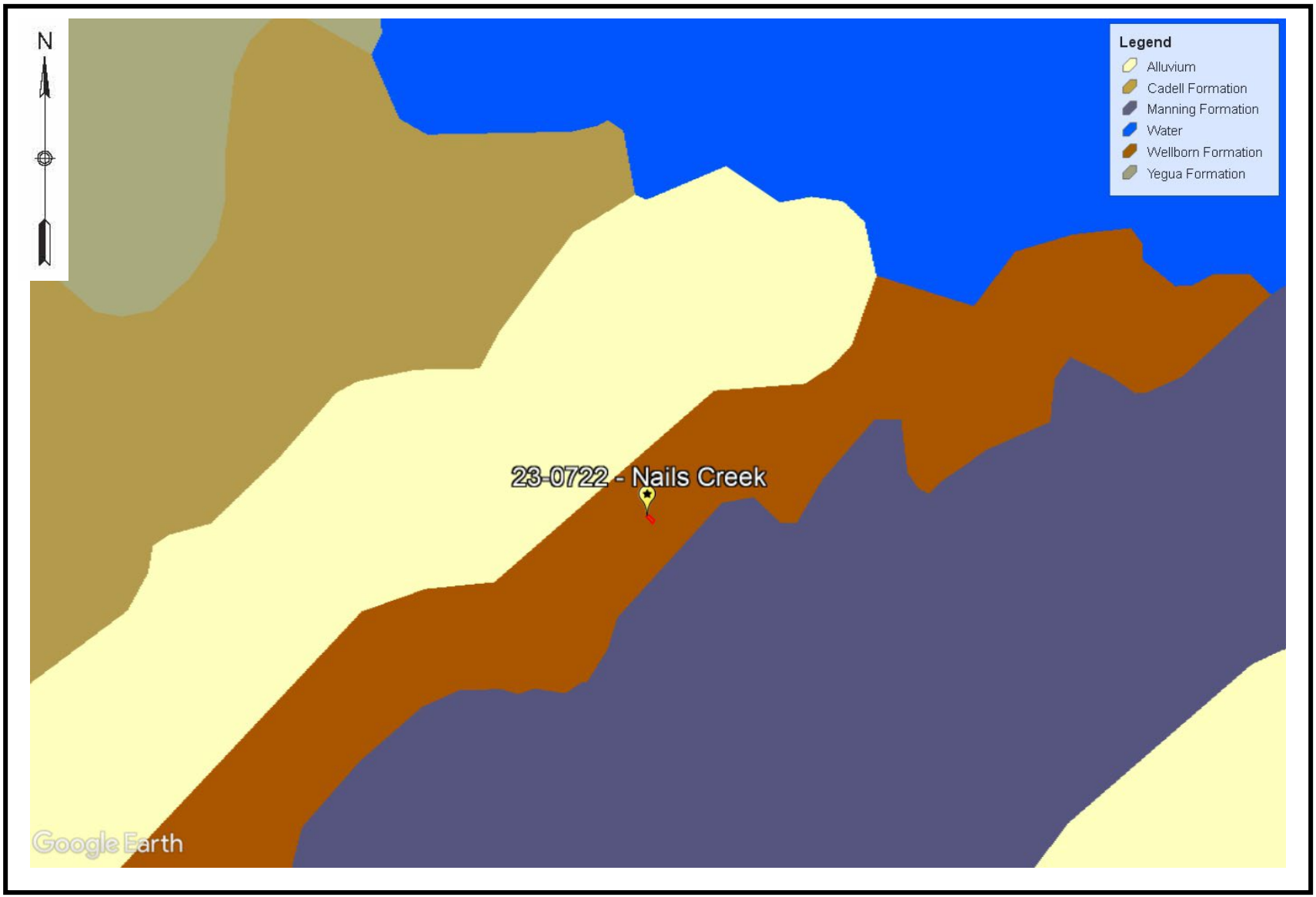
Boring B-02 Facing Northwest

Boring B-03 Facing West

Boring B-04 Facing Southwest

Appendix - Geologic Information

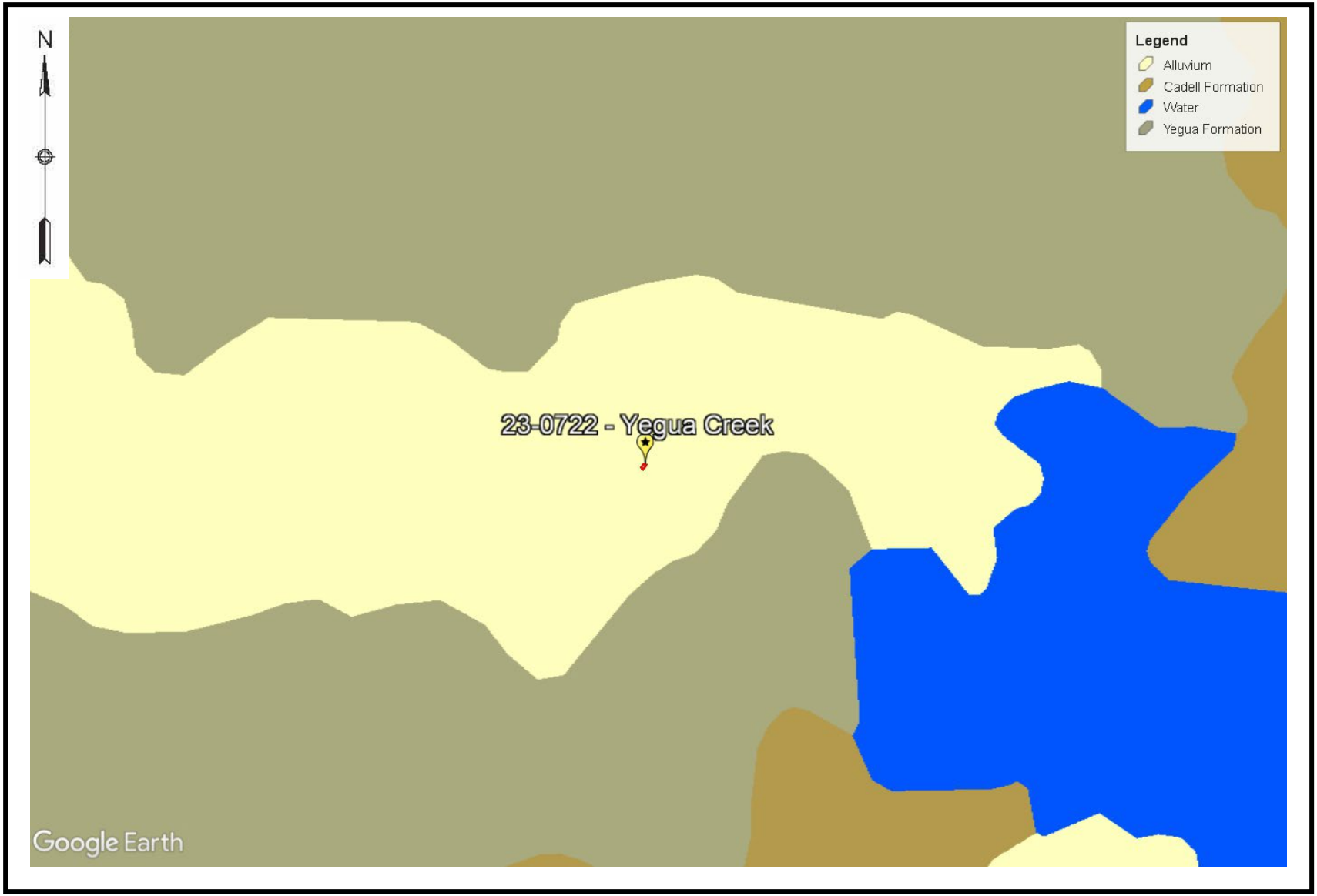
GEOLOGIC ATLAS – YEGUA CREEK



Project No. 23-0722

Lake Somerville Trailway Bridge Replacement

GEOLOGIC ATLAS – SOMERVILLE TRAILWAY



Project No. 23-0722

Lake Somerville Trailway Bridge Replacement

Mineral Resources On-Line Spatial Data

Wellborn Formation

Wellborn Formation

State	Texas
Name	Wellborn Formation
Geologic age	Phanerozoic | Cenozoic | Tertiary | Eocene
Original map label	Ewb
Comments	In north, central, and south Texas including Quaternary for all of west Texas- Sandstone, fine to coarse grained, lt gray, crossbedded, contains borings of worms and Ophiomorpha burrows and fossil shells; locally well indurated; thickness about 150 ft. In East Texas and Gulf Coast to Rio Grande- quartz sand, v. fine to fine grained, sl. glauconitic, increasingly glauconitic eastward (in Palestine Sheet (1968), interbeds of brown lignitic clay and lignite; lt. brown, weathers dk gray; marine megafossils locally; thickness 50 ft, feathers out eastward
Primary rock type	sandstone
Secondary rock type	sand
Other rock types	clay or mud; coal
Lithologic constituents	Major Sedimentary > Clastic > Sandstone *(Glauconitic)* Incidental Sedimentary > Coal > Lignite *(Bed)* Sedimentary > Clastic > Mudstone > Claystone *(Bed)*
Map references	Bureau of Economic Geology, 1992, Geologic Map of Texas: University of Texas at Austin, Virgil E. Barnes, project supervisor, Hartmann, B.M. and Scranton, D.F., cartography, scale 1:500,000
Unit references	Bureau of Economic Geology, 1976, Crystal City-Eagle Pass Sheet, Geologic Atlas of Texas, University of Texas, Bureau of Economic Geology, scale 1:250,000.

Mineral Resources On-Line Spatial Data

alluvium

alluvium

State	Texas
Name	alluvium
Geologic age	Phanerozoic | Cenozoic | Quaternary | Holocene
Original map label	Qal
Comments	alluvium and low terrace deposits along streams, sand, silt, clay, and gravel. Thickness variable. The unit appears on Geologic Map of Texas on the lagoon side of barrier islands where they represent lagoon and wind-tidal-flat sand and clay. These deposits of clay and silty, clayey fine to v. fine quartz sand and shell sand accumulate on alternately dry and flooded barren flats 0.3 m below to 1 m above mean sea level. Mapped areas include active eolian sand dunes on the landward side of barrier islands.
Primary rock type	sand
Secondary rock type	silt
Other rock types	clay or mud; gravel
Lithologic constituents	Major Unconsolidated > Coarse-detrital *(Alluvial)* Unconsolidated > Fine-detrital *(Alluvial)*
Map references	Bureau of Economic Geology, 1992, Geologic Map of Texas: University of Texas at Austin, Virgil E. Barnes, project supervisor, Hartmann, B.M. and Scranton, D.F., cartography, scale 1:500,000
Unit references	Bureau of Economic Geology, 1974, Austin Sheet, Geologic Atlas of Texas, University of Texas, Bureau of Economic Geology, scale 1:250,000. Bureau of Economic Geology, 1974, San Antonio Sheet, Geologic Atlas of Texas, University of Texas, Bureau of Economic Geology, scale 1:250,000. Bureau of Economic Geology, 1976, Crystal City-Eagle Pass Sheet, Geologic Atlas of Texas, University of Texas, Bureau of Economic Geology, scale 1:250,000.

Mineral Resources On-Line Spatial Data

Manning Formation

Manning Formation

State	Texas
Name	Manning Formation
Geologic age	Phanerozoic | Cenozoic | Tertiary | Eocene
Original map label	Em
Comments	clay and sandstone, chiefly clay, massive to laminated, sl. carbonaceous or lignitic, bentonitic, tuffaceous, thin interbeds of tuffaceous siltst; sandst in upper part, v. fine to fine grained, silty, well bedded to crossbedded; in lower part tuffaceous, contains fossil wood; thickness 250-350 ft. In East Texas and Gulf Coast to Rio Grande: Quartz sand, clay, and lignite. Sand, fine to med. grained, lignitic, light gray, weathers med. gray. Clay, sandy, lignitic, brn-gray; weathers pal brn-gray. Lignite brnish-black, weathers brn-gray. Fossil wood abdt. Thickness 200 ft.
Primary rock type	clay or mud
Secondary rock type	sand
Other rock types	bentonite; sandstone; siltstone; coal
Lithologic constituents	Major Sedimentary > Clastic > Mixed-clastic > Sandstone-mudstone *(Bed)* Incidental Sedimentary > Coal > Lignite *(Bed)*
Map references	Bureau of Economic Geology, 1992, Geologic Map of Texas: University of Texas at Austin, Virgil E. Barnes, project supervisor, Hartmann, B.M. and Scranton, D.F., cartography, scale 1:500,000
Unit references	Bureau of Economic Geology, 1967, Palestine Sheet, Geologic Atlas of Texas, Bureau of Economic Geology, University of Texas at Austin, scale 1:250,000.

Mineral Resources On-Line Spatial Data

Yegua Formation

Yegua Formation

State	Texas
Name	Yegua Formation
Geologic age	Phanerozoic | Cenozoic | Tertiary | Eocene-Middle
Original map label	Ey
Comments	clay with minor beds of sandstone, some concretionary limestone beds and lenses of oyster shells. sandst fine grained, calcar., glauconitic, massive, laminated, crossbedded; fossil wood; Volcanic ash included. silicified tuff containing an oyster and gastropod fauna (Eargle, 1968); 1,000 ft thick in San Antonio Sheet (1974). In East Texas and Gulf Coast to Rio Grande: Overlies Cook Mt. Formation; overlain by Caddell Fm. Unit is sandstone, clay, and lignite. Sandst. is mostly quartz and some chert, fine-grained, laminated, corssbedded; clay, lignitic, sandy, bentonitic, well laminated, lentils of lignite. In Seguin Sheet unit is about 1000 ft thick.
Primary rock type	clay or mud
Secondary rock type	sandstone
Other rock types	limestone; coal
Lithologic constituents	Major Sedimentary > Clastic > Sandstone *(Bed)* Sedimentary > Clastic > Mudstone > Claystone *(Bed)* Incidental Igneous > Volcanic *(Pyroclastic, air fall)* Sedimentary > Coal > Lignite *(Bed)* Sedimentary > Carbonate > Limestone *(Bed)*
Map references	Bureau of Economic Geology, 1992, Geologic Map of Texas: University of Texas at Austin, Virgil E. Barnes, project supervisor, Hartmann, B.M. and Scranton, D.F., cartography, scale 1:500,000
Unit references	Eargle, D.H., 1968, Nomenclature of formations of Claiborne Group, Middle Eocene, coastal plain of Texas: U.S. Geological Survey Bulletin 1251-D.

Mineral Resources On-Line Spatial Data

Cadell Formation

Cadell Formation

State	Texas
Name	Cadell Formation
Geologic age	Phanerozoic | Cenozoic | Tertiary | Eocene
Original map label	Eca
Comments	siltstone, clay, and sandstone; siltst tuffaceous; clay bentonitic locally fossiliferous; sandst. v. fine grained, glauconitic, lt. gray to olive; thickness 50 ft in San Anotonio and Crystal City Sheets 50-100 ft in Seguin Sheet In East Texas and Gulf Coast to Rio Grande: Clay and quartz sand. Clay sandy, lignitic, brown; sand, v. fine grained, glauconitic, glauconitic ironstone concretions common; thickness 25-45 ft
Primary rock type	siltstone
Secondary rock type	clay or mud
Other rock types	sandstone; sand
Lithologic constituents	Major Sedimentary > Clastic > Sandstone *(Bed)* Sedimentary > Clastic > Mudstone > Claystone *(Bed)* Minor Sedimentary > Clastic > Siltstone *(Bed)*
Map references	Bureau of Economic Geology, 1992, Geologic Map of Texas: University of Texas at Austin, Virgil E. Barnes, project supervisor, Hartmann, B.M. and Scranton, D.F., cartography, scale 1:500,000
Unit references	Bureau of Economic Geology, 1974, San Antonio Sheet, Geologic Atlas of Texas, University of Texas, Bureau of Economic Geology, scale 1:250,000. Bureau of Economic Geology, 1974, Seguin Sheet, Geologic Atlas of Texas, University of Texas, Bureau of Economic Geology, scale 1:250,000. Bureau of Economic Geology, 1976, Crystal City-Eagle Pass Sheet, Geologic Atlas of Texas, University of Texas, Bureau of Economic

Appendix F - Axial Capacities of Drilled Piers and Driven Piles

TCP METHOD - DRILLED PIERS

SOIL STRENGTH ANALYSIS

WinCore
Version 3.3

County		Hole	B-01	District	Somerville
Highway		Structure	Bridge	Date	1/10/2024
Control		Station		Grnd. Elev.	0.00 ft
		Offset		GW Elev.	-18.00 ft

TCP Capacity Values Used

Soil reduction factor of 0.7 applied

Strata No.	Elev. (Feet) From	To	Design Type	Soil Factor	TCP N Value	TCP Unit Friction (TSF)	Accumulative Friction (T/F)
1	0.0	-8.0	SC	70	9	0.09	0.72
1	-8.0	-13.0	SC	70	8	0.08	1.12
2	-13.0	-18.0	CH	50	6	0.08	1.54
2	-18.0	-23.0	CH	50	10	0.14	2.24
2	-23.0	-28.0	CH	50	29	0.41	4.27
3	-28.0	-33.0	CH	50	48	0.67	7.63
3	-33.0	-38.0	CH	50	59	0.83	11.76
3	-38.0	-43.0	CH	50	63	0.88	16.17
3	-43.0	-48.0	CH	50	67	0.94	20.86
3	-48.0	-53.0	CH	50	75	1.05	26.11
3	-53.0	-57.5	CH	50	105	0.85	29.94
3	-57.5	-60.0	CH	50	109	0.85	32.06

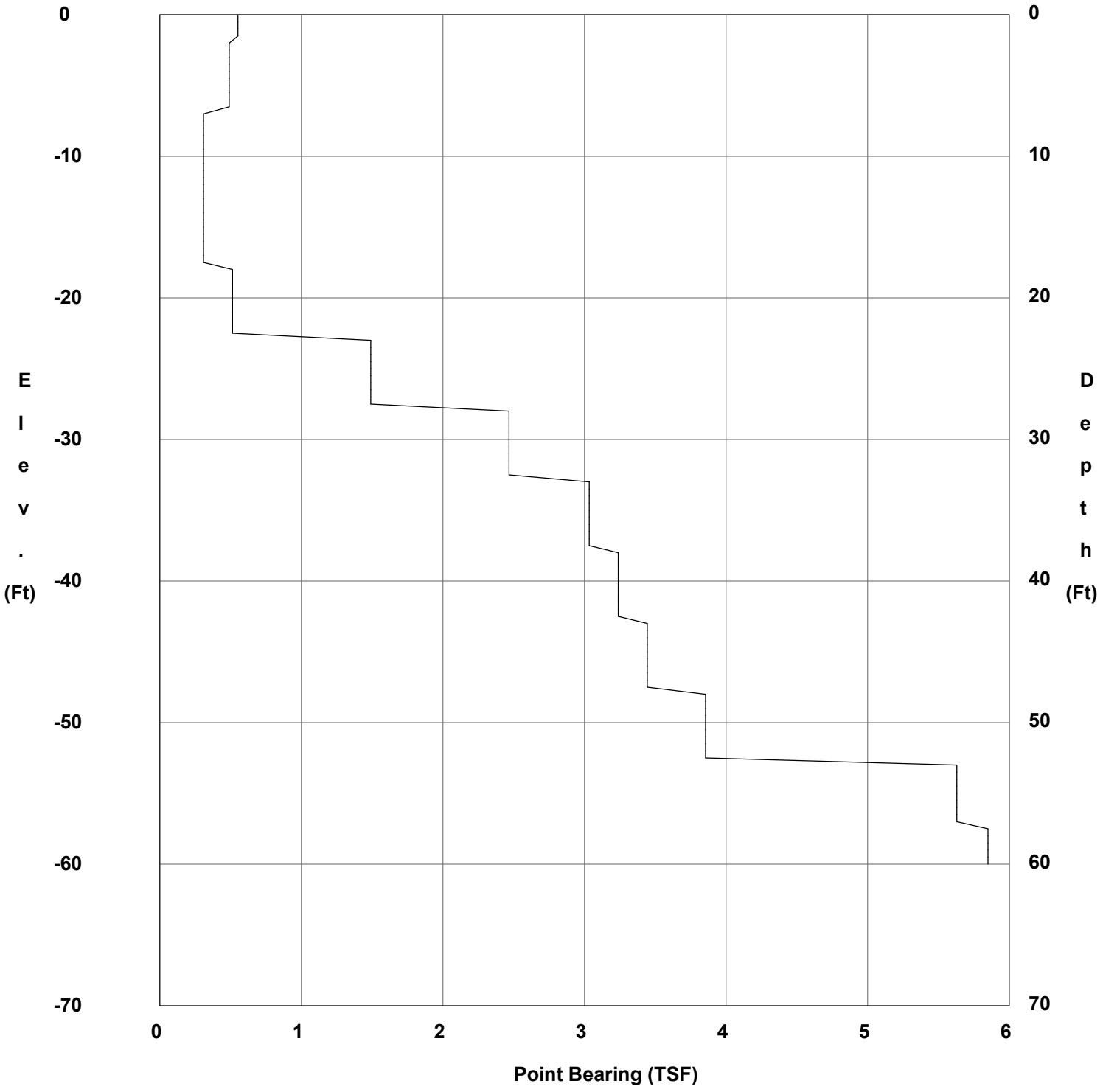
POINT BEARING DESIGN

WinCore
Version 3.3

County		Hole	B-01	District	Somerville
Highway		Structure	Bridge	Date	1/10/2024
Control		Station		Grnd. Elev.	0.00 ft
		Offset		GW Elev.	-18.00 ft

Diameters Below Tip Checked = 2

TCP Bearing Values Used



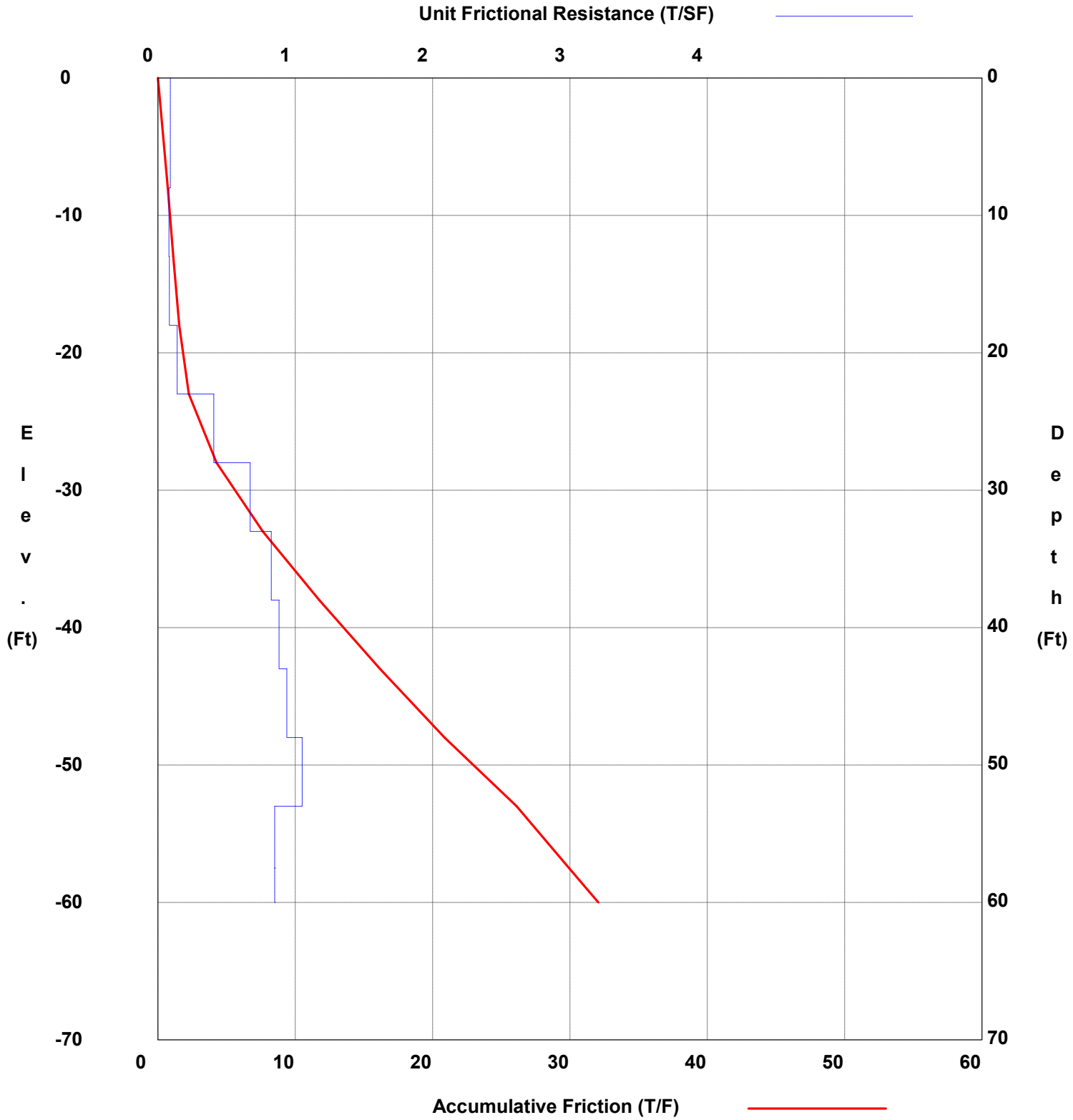
SKIN FRICTION DESIGN

WinCore
Version 3.3

County		Hole	B-01	District	Somerville
Highway		Structure	Bridge	Date	1/10/2024
Control		Station		Grnd. Elev.	0.00 ft
		Offset		GW Elev.	-18.00 ft

Drilled Shaft Design: Soil Reduction Factor = 0.7

TCP Friction Values Used



SOIL STRENGTH ANALYSIS

WinCore
Version 3.3

County		Hole	B-02	District	Somerville
Highway		Structure	Bridge	Date	1/19/2024
Control		Station		Grnd. Elev.	0.00 ft
		Offset		GW Elev.	-22.00 ft

TCP Capacity Values Used

Soil reduction factor of 0.7 applied

Strata No.	Elev. (Feet) From	To	Design Type	Soil Factor	TCP N Value	TCP Unit Friction (TSF)	Accumulative Friction (T/F)
1	0.0	-2.0	SC	70	0	0.00	0.00
2	-2.0	-8.0	CL	60	37	0.43	2.59
3	-8.0	-13.0	SC	70	47	0.47	4.94
3	-13.0	-18.0	SC	70	24	0.24	6.14
4	-18.0	-23.0	CH	50	31	0.43	8.31
4	-23.0	-28.0	CH	50	60	0.84	12.51
4	-28.0	-33.0	CH	50	72	1.01	17.55
4	-33.0	-38.0	CH	50	185	1.04	22.74
4	-38.0	-43.0	CH	50	171	0.96	27.56
4	-43.0	-48.0	CH	50	200	1.12	33.18
4	-48.0	-53.0	CH	50	185	1.04	38.37
5	-53.0	-57.5	SC	70	171	0.96	42.71
5	-57.5	-60.0	SC	70	171	0.96	45.12

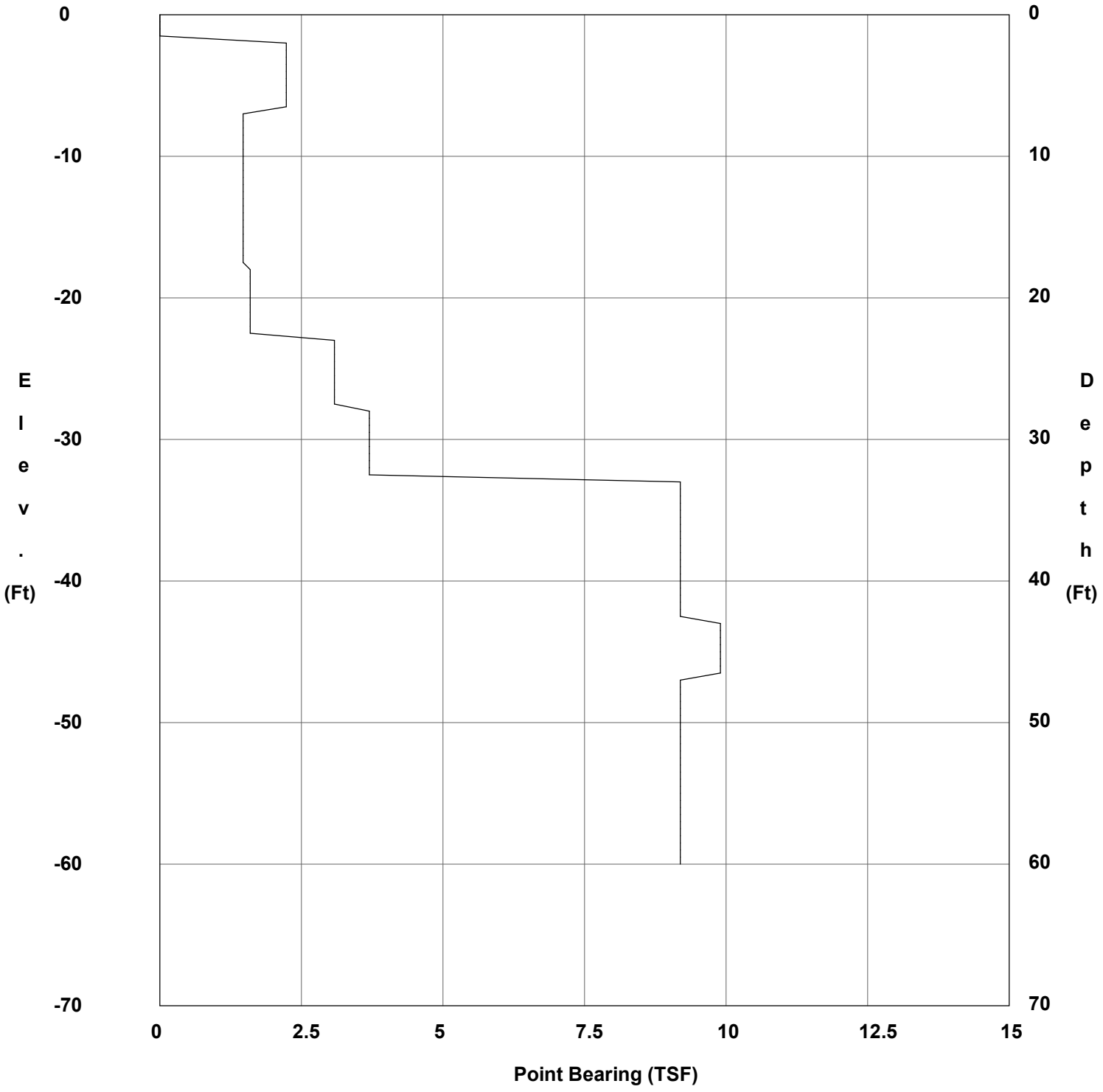
POINT BEARING DESIGN

WinCore
Version 3.3

County		Hole	B-02	District	Somerville
Highway		Structure	Bridge	Date	1/19/2024
Control		Station		Grnd. Elev.	0.00 ft
		Offset		GW Elev.	-22.00 ft

Diameters Below Tip Checked = 2

TCP Bearing Values Used



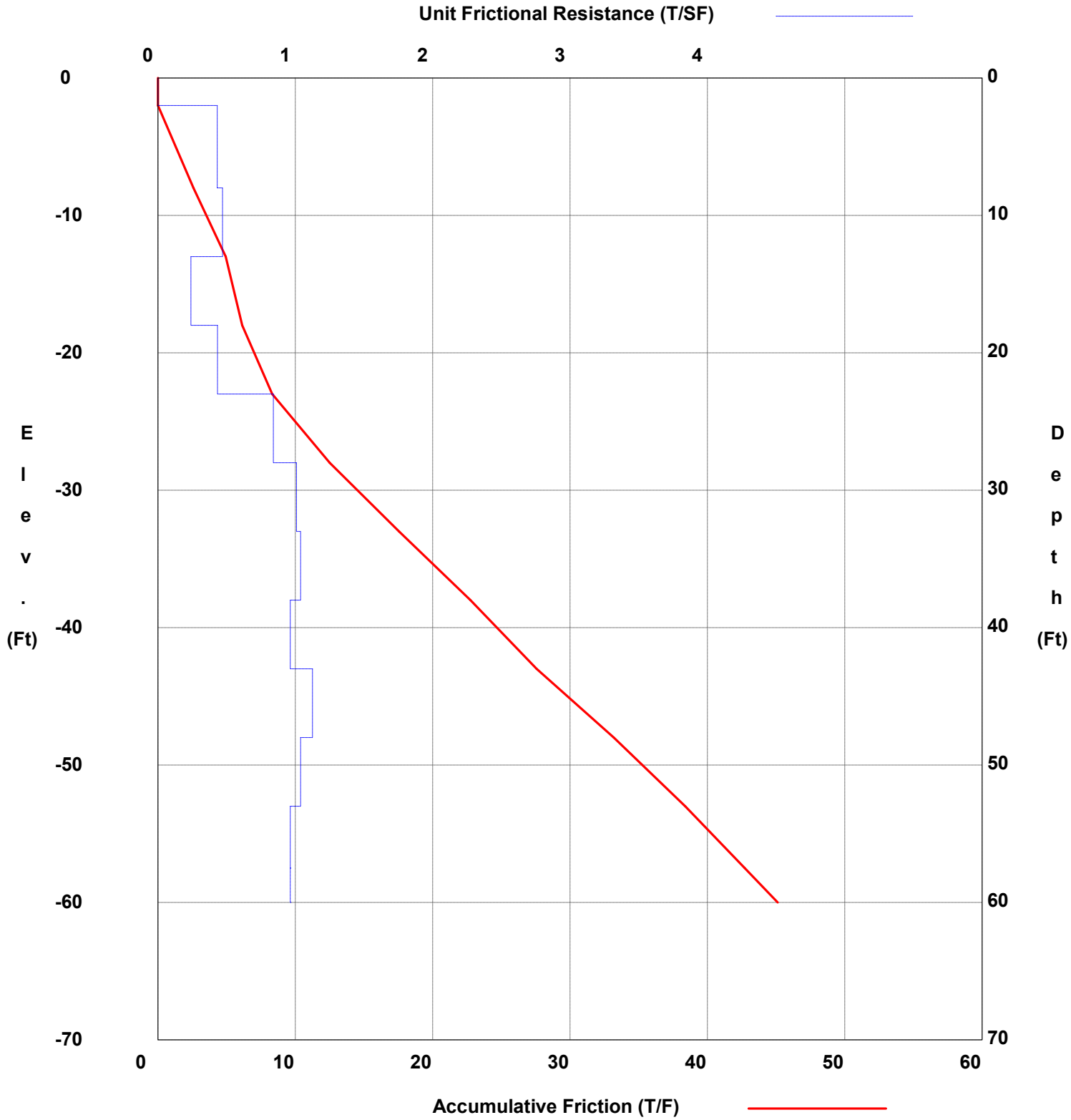
SKIN FRICTION DESIGN

WinCore
Version 3.3

County		Hole	B-02	District	Somerville
Highway		Structure	Bridge	Date	1/19/2024
Control		Station		Grnd. Elev.	0.00 ft
		Offset		GW Elev.	-22.00 ft

Drilled Shaft Design: Soil Reduction Factor = 0.7

TCP Friction Values Used



SOIL STRENGTH ANALYSIS

WinCore
Version 3.3

County		Hole	B-03	District	Somerville
Highway		Structure	Bridge	Date	1/4/2024
Control		Station		Grnd. Elev.	0.00 ft
		Offset		GW Elev.	-15.00 ft

TCP Capacity Values Used

Soil reduction factor of 0.7 applied

Strata No.	Elev. (Feet) From	To	Design Type	Soil Factor	TCP N Value	TCP Unit Friction (TSF)	Accumulative Friction (T/F)
1	0.0	-8.0	CH	50	25	0.35	2.80
2	-8.0	-13.0	OTHER	80	8	0.07	3.15
2	-13.0	-18.0	OTHER	80	2	0.02	3.24
2	-18.0	-23.0	OTHER	80	4	0.04	3.41
2	-23.0	-28.0	OTHER	80	37	0.32	5.03
2	-28.0	-33.0	OTHER	80	93	0.81	9.10
2	-33.0	-38.0	OTHER	80	240	1.35	15.85
2	-38.0	-43.0	OTHER	80	229	1.29	22.27
2	-43.0	-48.0	OTHER	80	178	1.00	27.27
2	-48.0	-53.0	OTHER	80	192	1.08	32.67
2	-53.0	-57.5	OTHER	80	178	1.00	37.17
2	-57.5	-60.0	OTHER	80	200	1.12	39.98

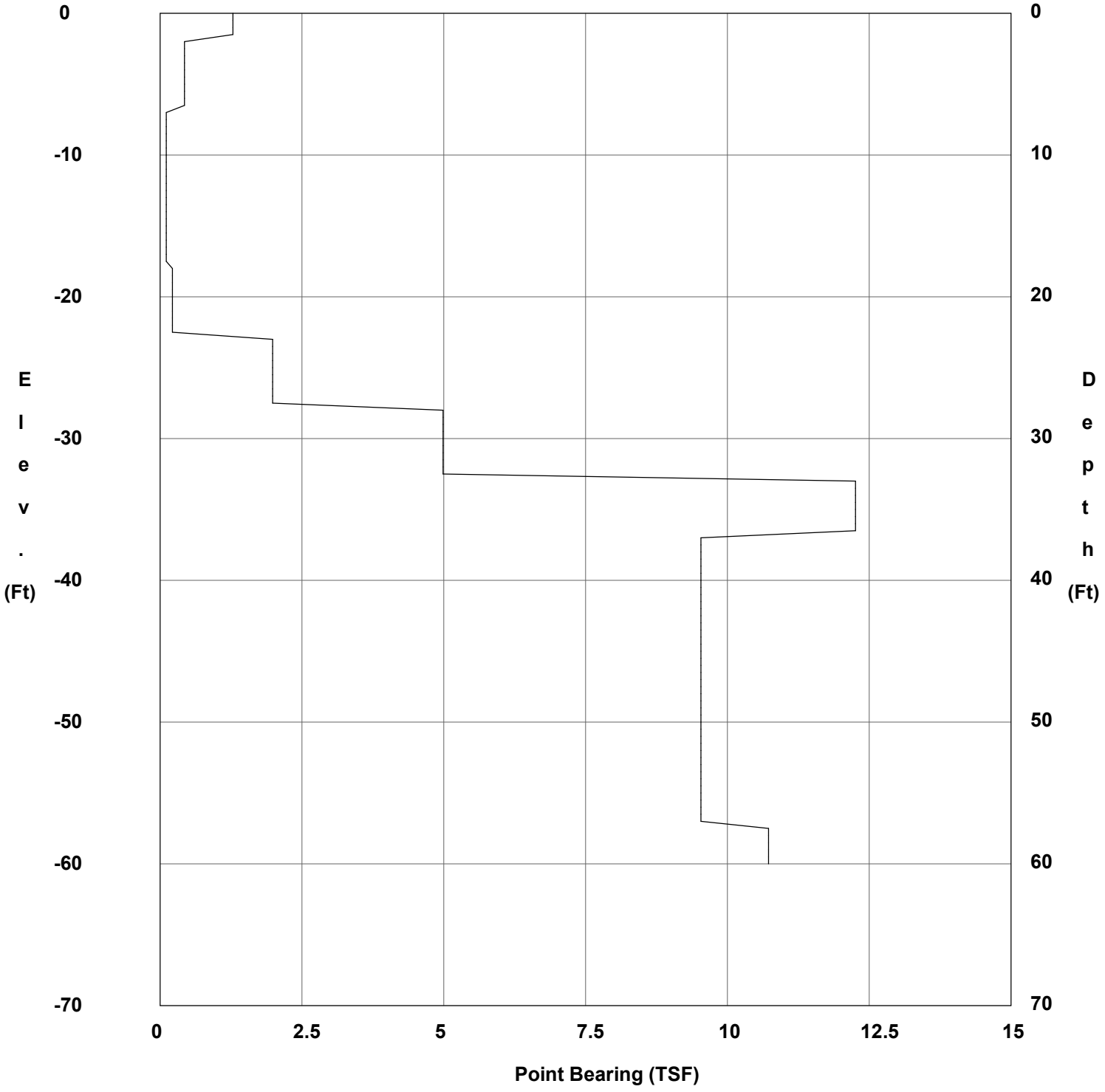
POINT BEARING DESIGN

WinCore
Version 3.3

County		Hole	B-03	District	Somerville
Highway		Structure	Bridge	Date	1/4/2024
Control		Station		Grnd. Elev.	0.00 ft
		Offset		GW Elev.	-15.00 ft

Diameters Below Tip Checked = 2

TCP Bearing Values Used



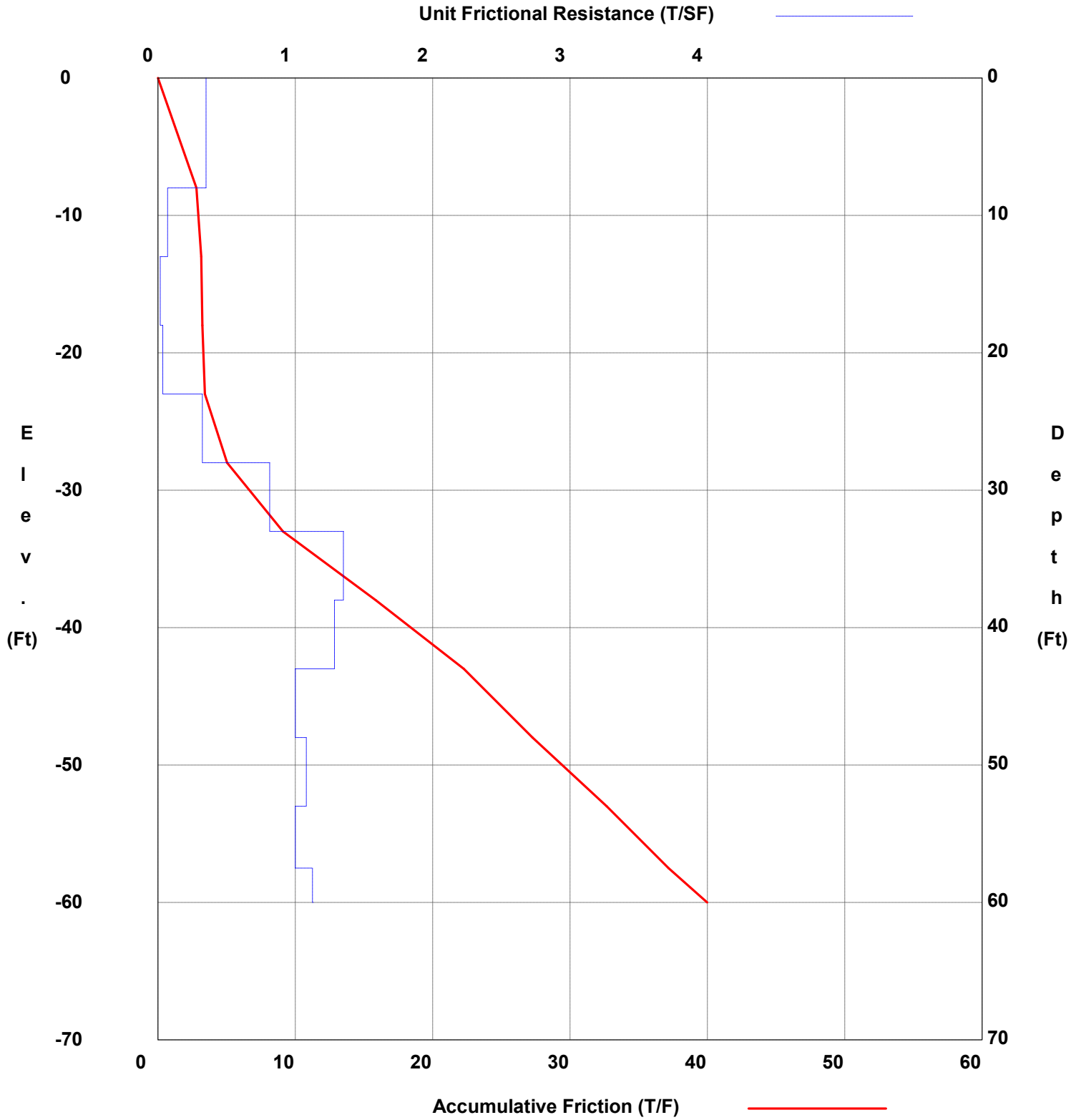
SKIN FRICTION DESIGN

WinCore
Version 3.3

County		Hole	B-03	District	Somerville
Highway		Structure	Bridge	Date	1/4/2024
Control		Station		Grnd. Elev.	0.00 ft
		Offset		GW Elev.	-15.00 ft

Drilled Shaft Design: Soil Reduction Factor = 0.7

TCP Friction Values Used



SOIL STRENGTH ANALYSIS

WinCore
Version 3.3

County		Hole	B-04	District	Somerville
Highway		Structure	Bridge	Date	1/10/2024
Control		Station		Grnd. Elev.	0.00 ft
		Offset		GW Elev.	-18.00 ft

TCP Capacity Values Used

Soil reduction factor of 0.7 applied

Strata No.	Elev. (Feet) From	To	Design Type	Soil Factor	TCP N Value	TCP Unit Friction (TSF)	Accumulative Friction (T/F)
1	0.0	-2.0	SC	70	0	0.00	0.00
2	-2.0	-8.0	CH	50	20	0.28	1.68
2	-8.0	-13.0	CH	50	14	0.20	2.66
3	-13.0	-18.0	OTHER	80	6	0.05	2.92
3	-18.0	-23.0	OTHER	80	4	0.04	3.10
3	-23.0	-28.0	OTHER	80	37	0.32	4.72
3	-28.0	-33.0	OTHER	80	95	0.83	8.87
3	-33.0	-38.0	OTHER	80	200	1.12	14.50
3	-38.0	-43.0	OTHER	80	150	0.85	18.75
3	-43.0	-48.0	OTHER	80	192	1.08	24.14
3	-48.0	-53.0	OTHER	80	171	0.96	28.96
3	-53.0	-57.5	OTHER	80	178	1.00	33.46
3	-57.5	-60.0	OTHER	80	200	1.12	36.27

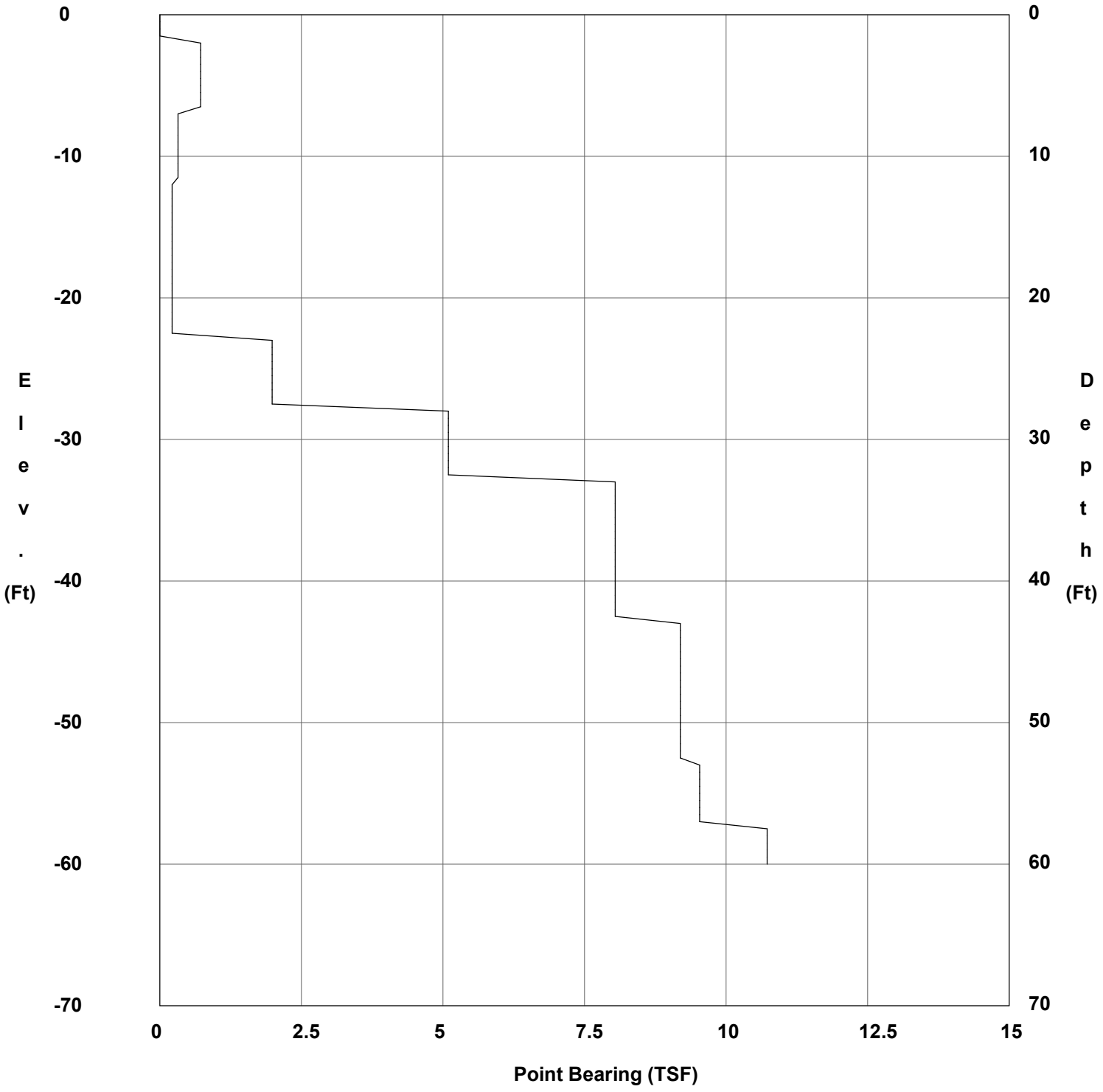
POINT BEARING DESIGN

WinCore
Version 3.3

County		Hole	B-04	District	Somerville
Highway		Structure	Bridge	Date	1/10/2024
Control		Station		Grnd. Elev.	0.00 ft
		Offset		GW Elev.	-18.00 ft

Diameters Below Tip Checked = 2

TCP Bearing Values Used



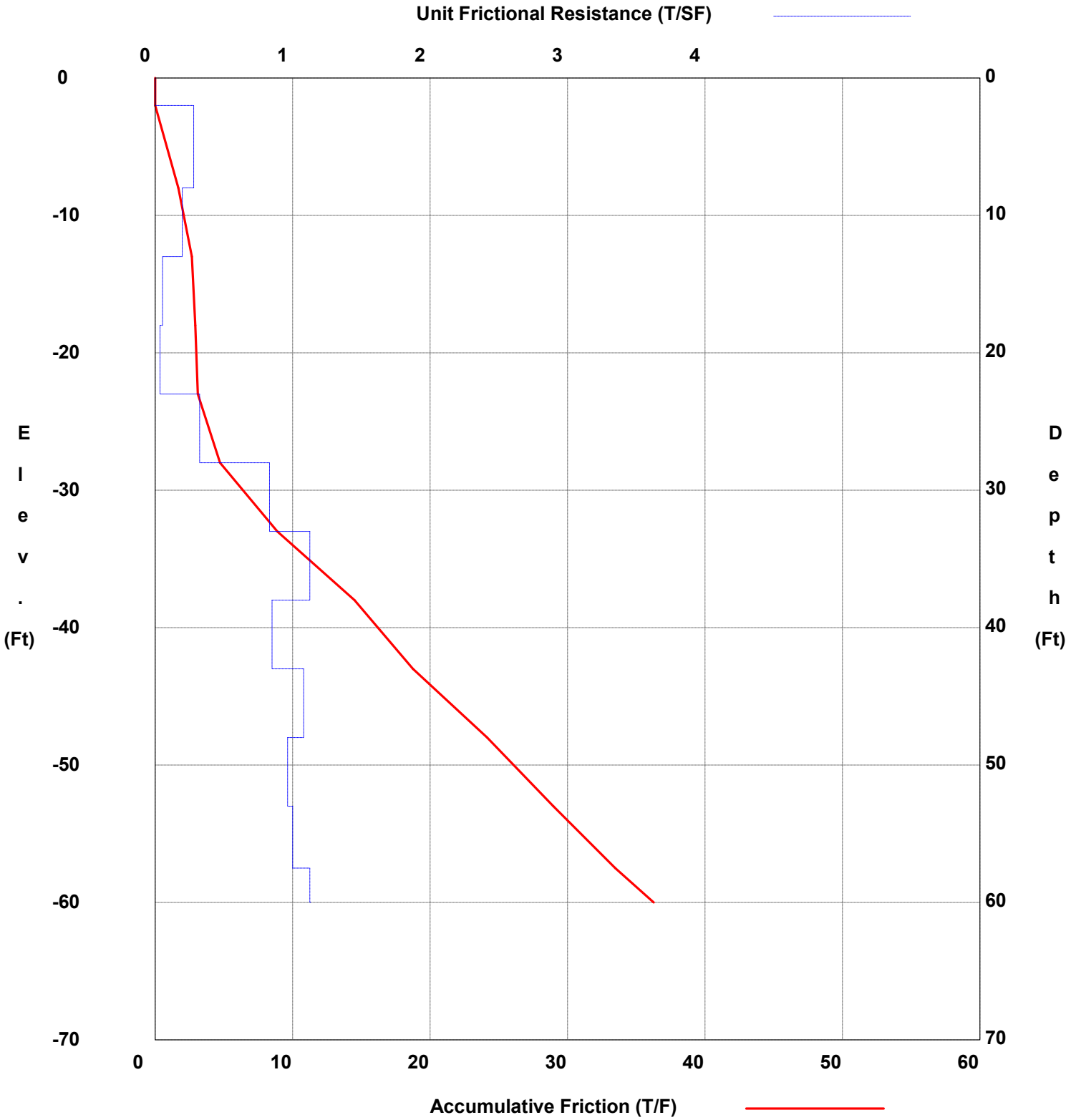
SKIN FRICTION DESIGN

WinCore
Version 3.3

County		Hole	B-04	District	Somerville
Highway		Structure	Bridge	Date	1/10/2024
Control		Station		Grnd. Elev.	0.00 ft
		Offset		GW Elev.	-18.00 ft

Drilled Shaft Design: Soil Reduction Factor = 0.7

TCP Friction Values Used



TCP METHOD - DRIVEN PILES

SOIL STRENGTH ANALYSIS

WinCore
Version 3.3

County		Hole	B-01	District	Somerville
Highway		Structure	Bridge	Date	1/10/2024
Control		Station		Grnd. Elev.	0.00 ft
		Offset		GW Elev.	-18.00 ft

TCP Capacity Values Used **Skin Friction Limit = 1.40 tsf** **No soil reduction factor applied**

Strata No.	Elev. (Feet) From	To	Design Type	Soil Factor	TCP N Value	TCP Unit Friction (TSF)	Accumulative Friction (T/F)
1	0.0	-8.0	SC	70	9	0.13	1.03
1	-8.0	-13.0	SC	70	8	0.11	1.60
2	-13.0	-18.0	CH	50	6	0.12	2.20
2	-18.0	-23.0	CH	50	10	0.20	3.20
2	-23.0	-28.0	CH	50	29	0.58	6.10
3	-28.0	-33.0	CH	50	48	0.96	10.90
3	-33.0	-38.0	CH	50	59	1.18	16.80
3	-38.0	-43.0	CH	50	63	1.26	23.10
3	-43.0	-48.0	CH	50	67	1.34	29.80
3	-48.0	-53.0	CH	50	75	1.40	36.80
3	-53.0	-57.5	CH	50	105	0.85	40.63
3	-57.5	-60.0	CH	50	109	0.85	42.75

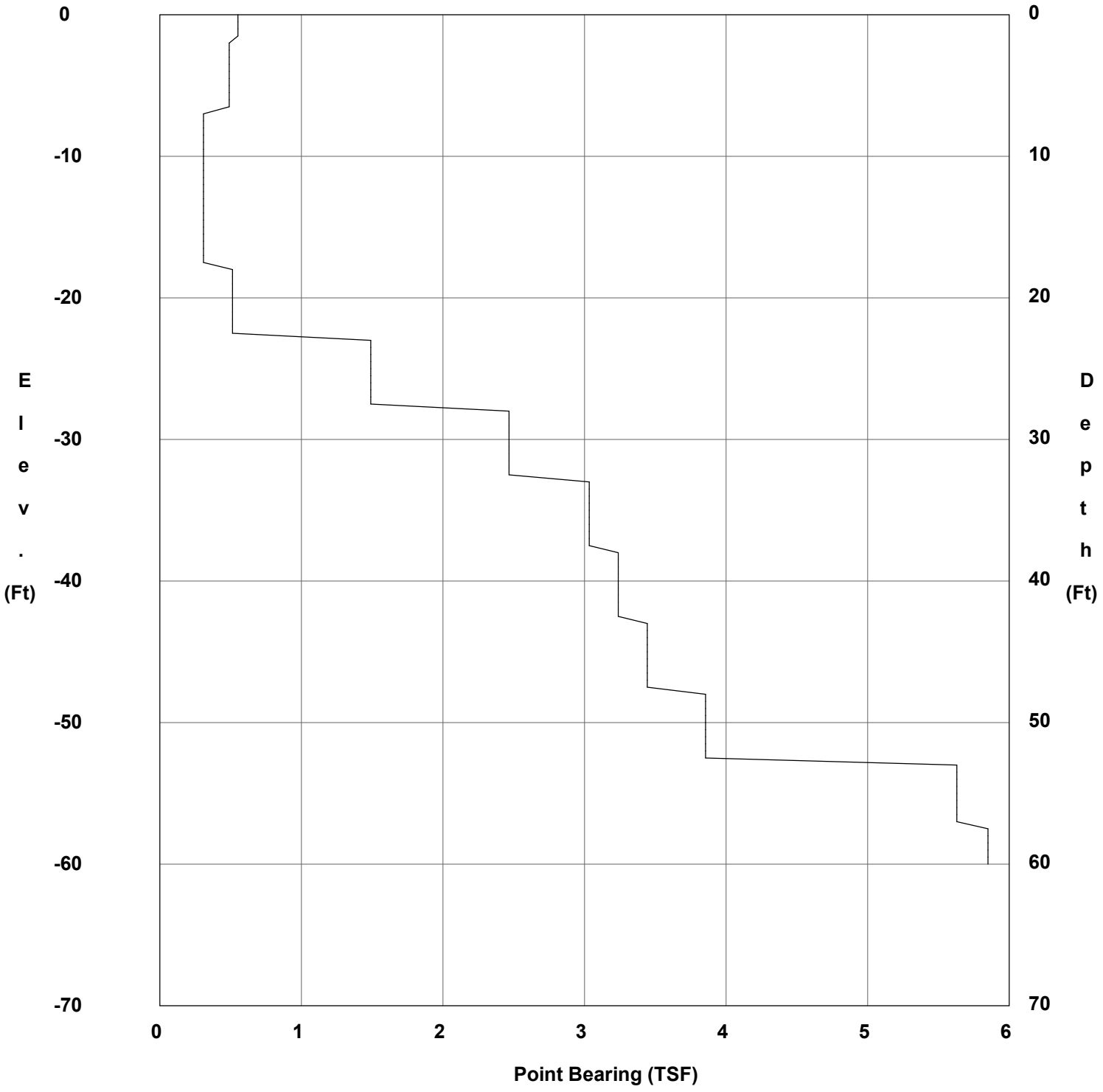
POINT BEARING DESIGN

WinCore
Version 3.3

County		Hole	B-01	District	Somerville
Highway		Structure	Bridge	Date	1/10/2024
Control		Station		Grnd. Elev.	0.00 ft
		Offset		GW Elev.	-18.00 ft

Diameters Below Tip Checked = 2

TCP Bearing Values Used



SKIN FRICTION DESIGN

WinCore
Version 3.3

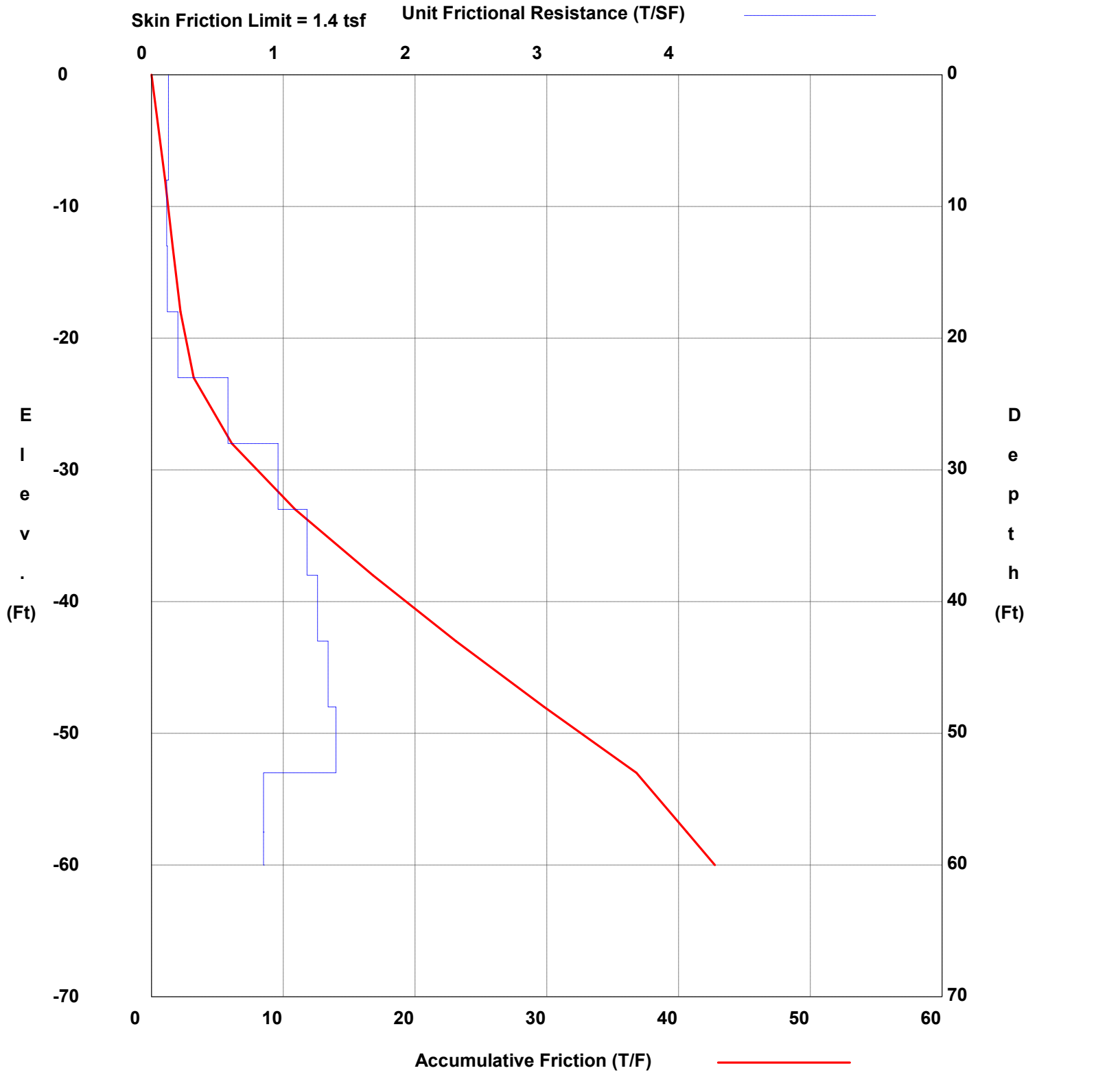
County		Hole	B-01	District	Somerville
Highway		Structure	Bridge	Date	1/10/2024
Control		Station		Grnd. Elev.	0.00 ft
		Offset		GW Elev.	-18.00 ft

Piling Design: No Soil Reduction Factor

Driving refusal maybe encountered below 28-feet

TCP Friction Values Used

Skin Friction Limit = 1.4 tsf



SOIL STRENGTH ANALYSIS

WinCore
Version 3.3

County		Hole	B-02	District	Somerville
Highway		Structure	Bridge	Date	1/19/2024
Control		Station		Grnd. Elev.	0.00 ft
		Offset		GW Elev.	-22.00 ft

TCP Capacity Values Used **Skin Friction Limit = 1.40 tsf** **No soil reduction factor applied**

Strata No.	Elev. (Feet) From	To	Design Type	Soil Factor	TCP N Value	TCP Unit Friction (TSF)	Accumulative Friction (T/F)
1	0.0	-2.0	SC	70	0	0.00	0.00
2	-2.0	-8.0	CL	60	37	0.62	3.70
3	-8.0	-13.0	SC	70	47	0.67	7.06
3	-13.0	-18.0	SC	70	24	0.34	8.77
4	-18.0	-23.0	CH	50	31	0.62	11.87
4	-23.0	-28.0	CH	50	60	1.20	17.87
4	-28.0	-33.0	CH	50	72	1.40	24.87
4	-33.0	-38.0	CH	50	185	1.04	30.06
4	-38.0	-43.0	CH	50	171	0.96	34.88
4	-43.0	-48.0	CH	50	200	1.12	40.50
4	-48.0	-53.0	CH	50	185	1.04	45.70
5	-53.0	-57.5	SC	70	171	0.96	50.03
5	-57.5	-60.0	SC	70	171	0.96	52.44

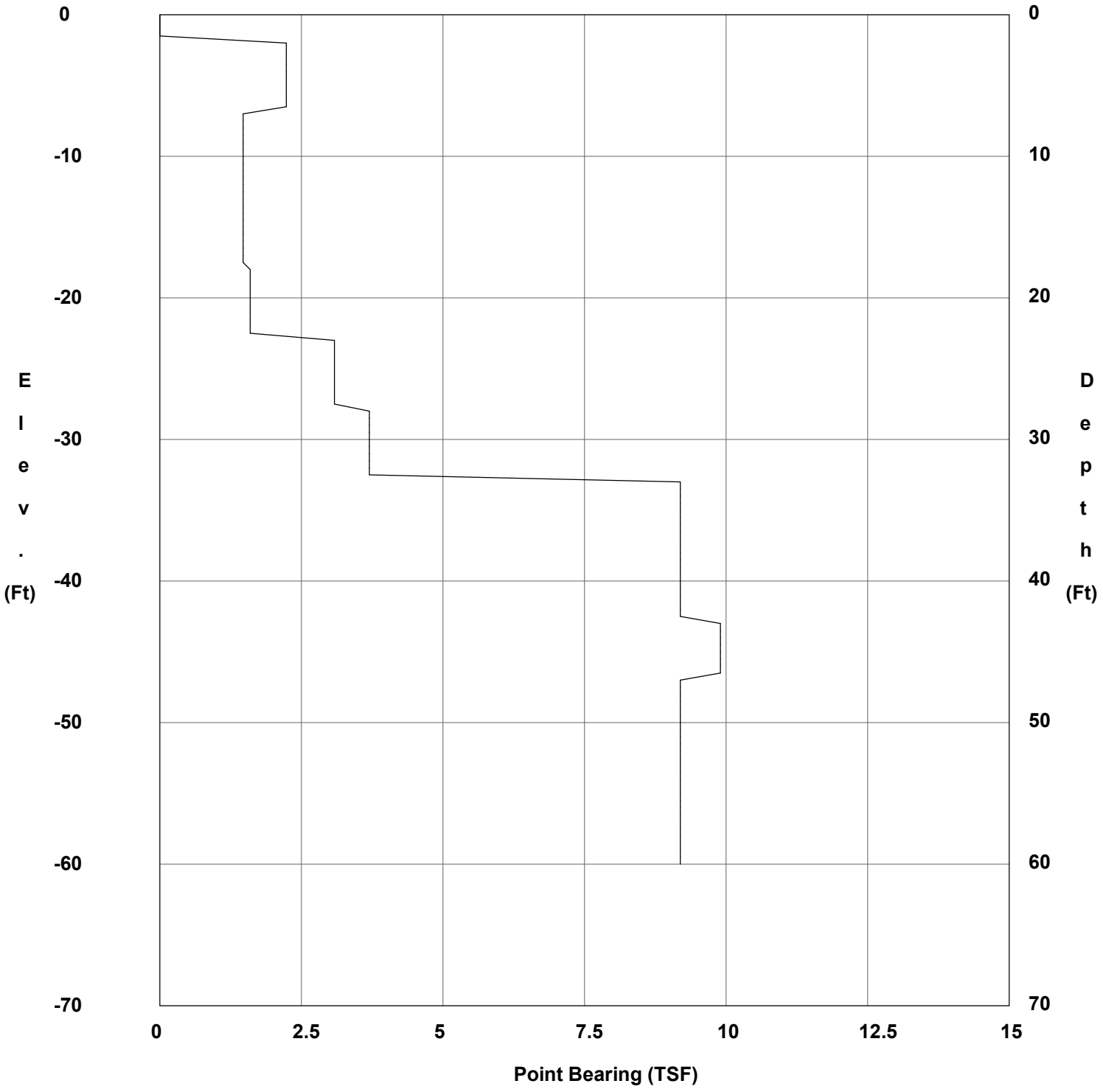
POINT BEARING DESIGN

WinCore
Version 3.3

County		Hole	B-02	District	Somerville
Highway		Structure	Bridge	Date	1/19/2024
Control		Station		Grnd. Elev.	0.00 ft
		Offset		GW Elev.	-22.00 ft

Diameters Below Tip Checked = 2

TCP Bearing Values Used



SKIN FRICTION DESIGN

WinCore
Version 3.3

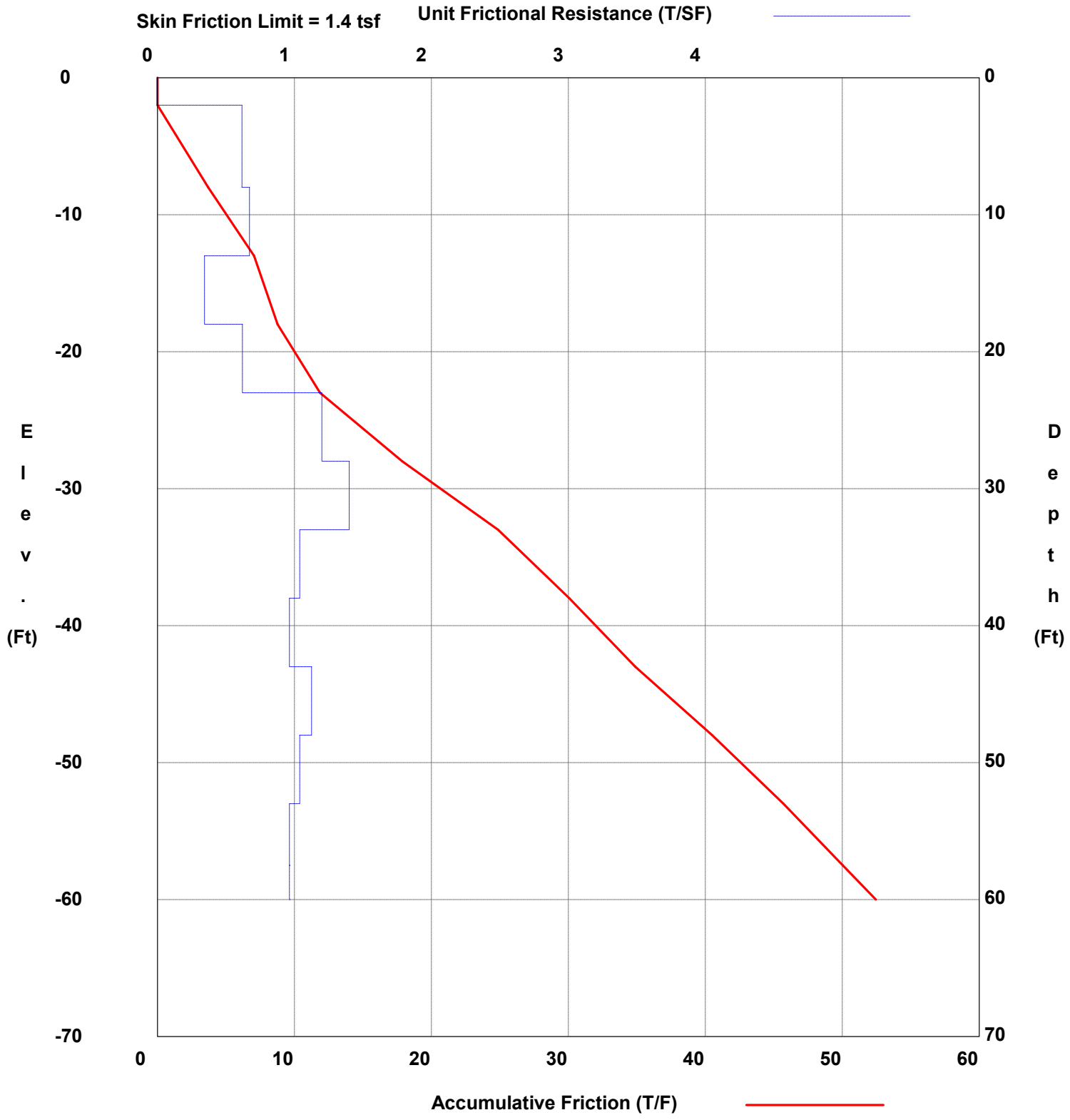
County		Hole	B-02	District	Somerville
Highway		Structure	Bridge	Date	1/19/2024
Control		Station		Grnd. Elev.	0.00 ft
		Offset		GW Elev.	-22.00 ft

Piling Design: No Soil Reduction Factor

Driving refusal maybe encountered below 18-feet

TCP Friction Values Used

Skin Friction Limit = 1.4 tsf



SOIL STRENGTH ANALYSIS

WinCore
Version 3.3

County		Hole	B-03	District	Somerville
Highway		Structure	Bridge	Date	1/4/2024
Control		Station		Grnd. Elev.	0.00 ft
		Offset		GW Elev.	-15.00 ft

TCP Capacity Values Used **Skin Friction Limit = 1.40 tsf** **No soil reduction factor applied**

Strata No.	Elev. (Feet) From	To	Design Type	Soil Factor	TCP N Value	TCP Unit Friction (TSF)	Accumulative Friction (T/F)
1	0.0	-8.0	CH	50	25	0.50	4.00
2	-8.0	-13.0	OTHER	80	8	0.10	4.50
2	-13.0	-18.0	OTHER	80	2	0.03	4.63
2	-18.0	-23.0	OTHER	80	4	0.05	4.88
2	-23.0	-28.0	OTHER	80	37	0.46	7.19
2	-28.0	-33.0	OTHER	80	93	1.16	13.00
2	-33.0	-38.0	OTHER	80	240	1.35	19.75
2	-38.0	-43.0	OTHER	80	229	1.29	26.17
2	-43.0	-48.0	OTHER	80	178	1.00	31.17
2	-48.0	-53.0	OTHER	80	192	1.08	36.57
2	-53.0	-57.5	OTHER	80	178	1.00	41.07
2	-57.5	-60.0	OTHER	80	200	1.12	43.88

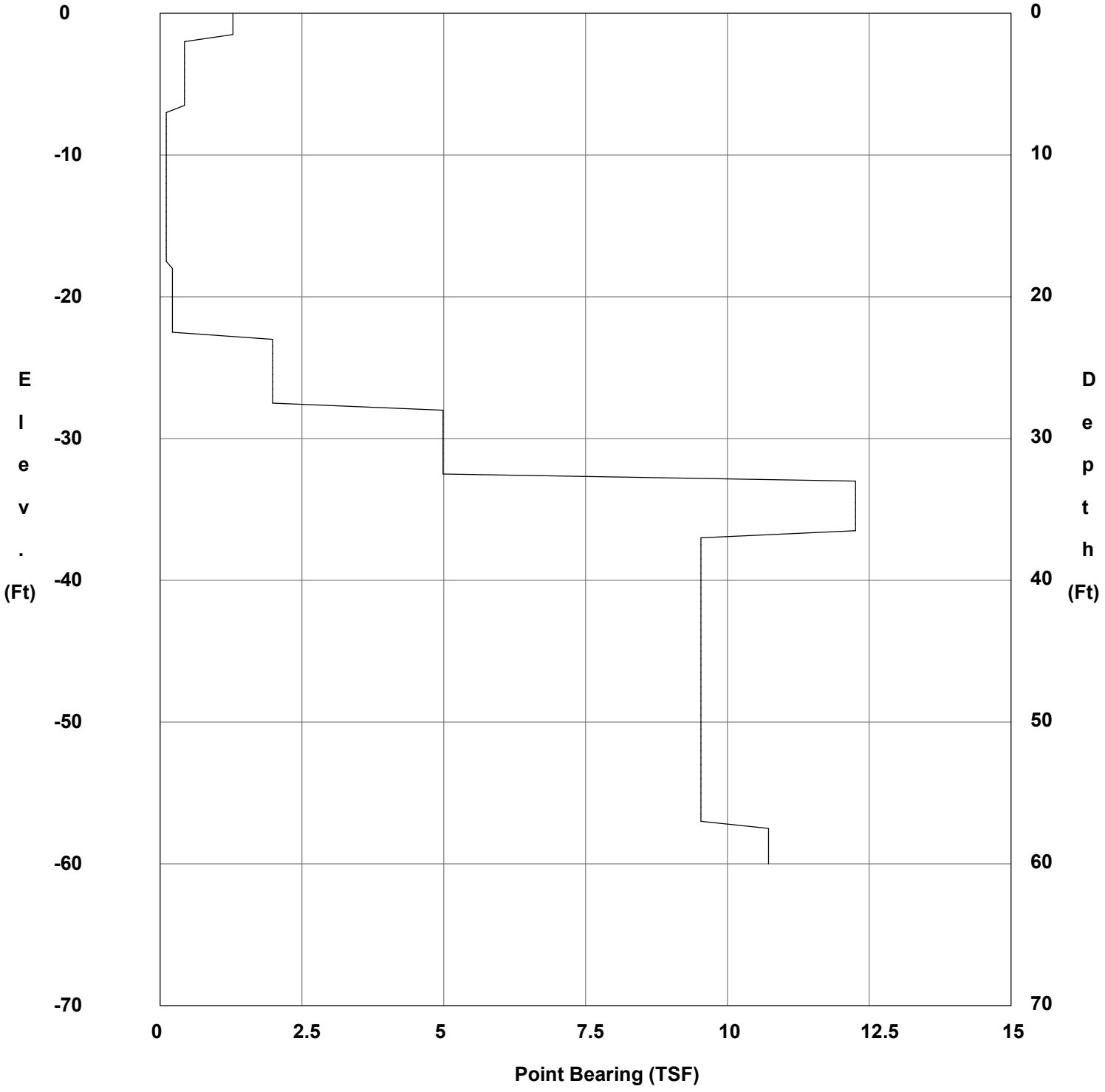
POINT BEARING DESIGN

WinCore
Version 3.3

County		Hole	B-03	District	Somerville
Highway		Structure	Bridge	Date	1/4/2024
Control		Station		Grnd. Elev.	0.00 ft
		Offset		GW Elev.	-15.00 ft

Diameters Below Tip Checked = 2

TCP Bearing Values Used



SKIN FRICTION DESIGN

WinCore
Version 3.3

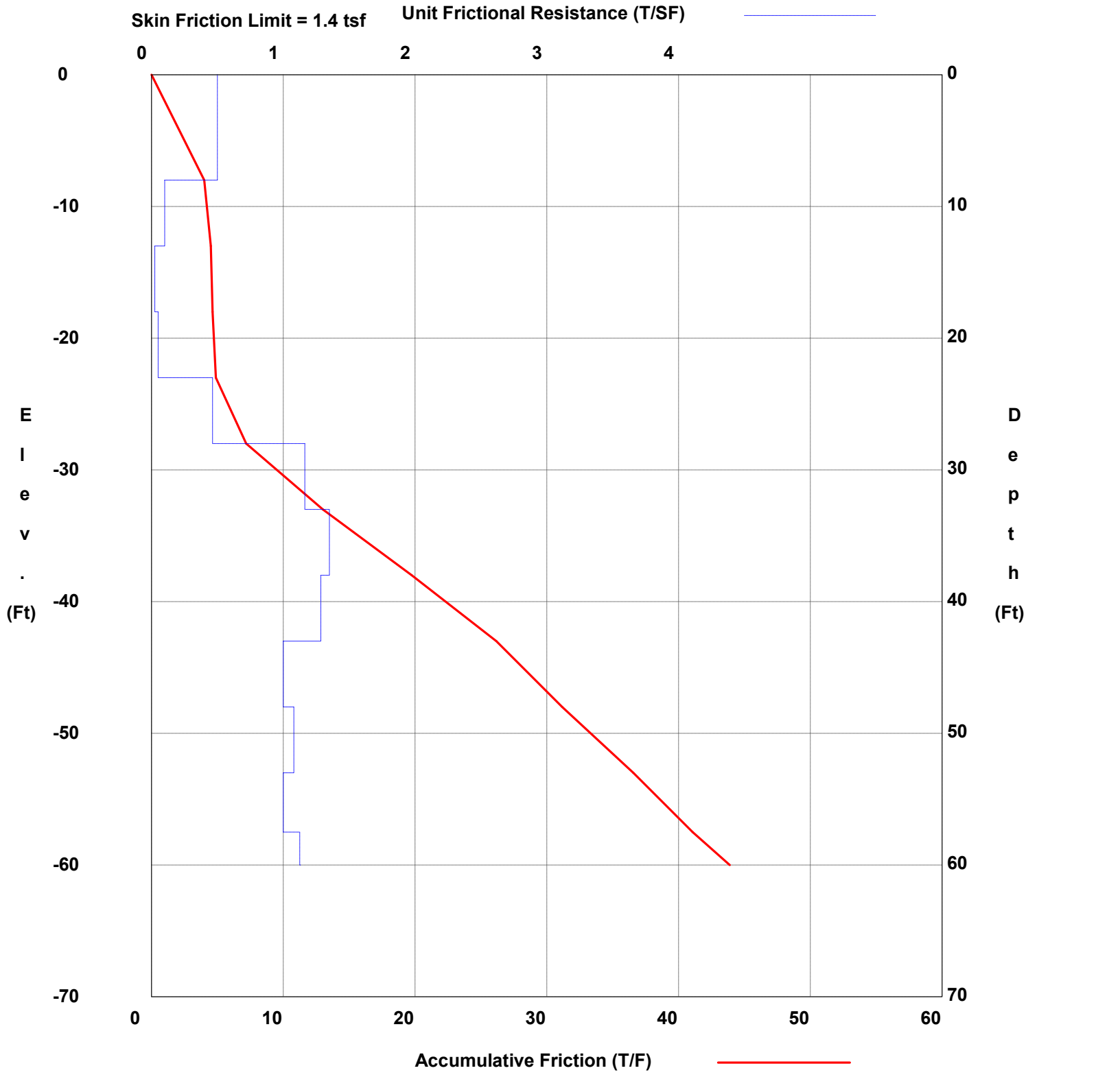
County		Hole	B-03	District	Somerville
Highway		Structure	Bridge	Date	1/4/2024
Control		Station		Grnd. Elev.	0.00 ft
		Offset		GW Elev.	-15.00 ft

Piling Design: No Soil Reduction Factor

Driving refusal maybe encountered below 20-feet

TCP Friction Values Used

Skin Friction Limit = 1.4 tsf



SOIL STRENGTH ANALYSIS

WinCore
Version 3.3

County		Hole	B-04	District	Somerville
Highway		Structure	Bridge	Date	1/10/2024
Control		Station		Grnd. Elev.	0.00 ft
		Offset		GW Elev.	-18.00 ft

TCP Capacity Values Used **Skin Friction Limit = 1.40 tsf** **No soil reduction factor applied**

Strata No.	Elev. (Feet) From	To	Design Type	Soil Factor	TCP N Value	TCP Unit Friction (TSF)	Accumulative Friction (T/F)
1	0.0	-2.0	SC	70	0	0.00	0.00
2	-2.0	-8.0	CH	50	20	0.40	2.40
2	-8.0	-13.0	CH	50	14	0.28	3.80
3	-13.0	-18.0	OTHER	80	6	0.08	4.18
3	-18.0	-23.0	OTHER	80	4	0.05	4.43
3	-23.0	-28.0	OTHER	80	37	0.46	6.74
3	-28.0	-33.0	OTHER	80	95	1.19	12.68
3	-33.0	-38.0	OTHER	80	200	1.12	18.30
3	-38.0	-43.0	OTHER	80	150	0.85	22.55
3	-43.0	-48.0	OTHER	80	192	1.08	27.95
3	-48.0	-53.0	OTHER	80	171	0.96	32.77
3	-53.0	-57.5	OTHER	80	178	1.00	37.26
3	-57.5	-60.0	OTHER	80	200	1.12	40.08

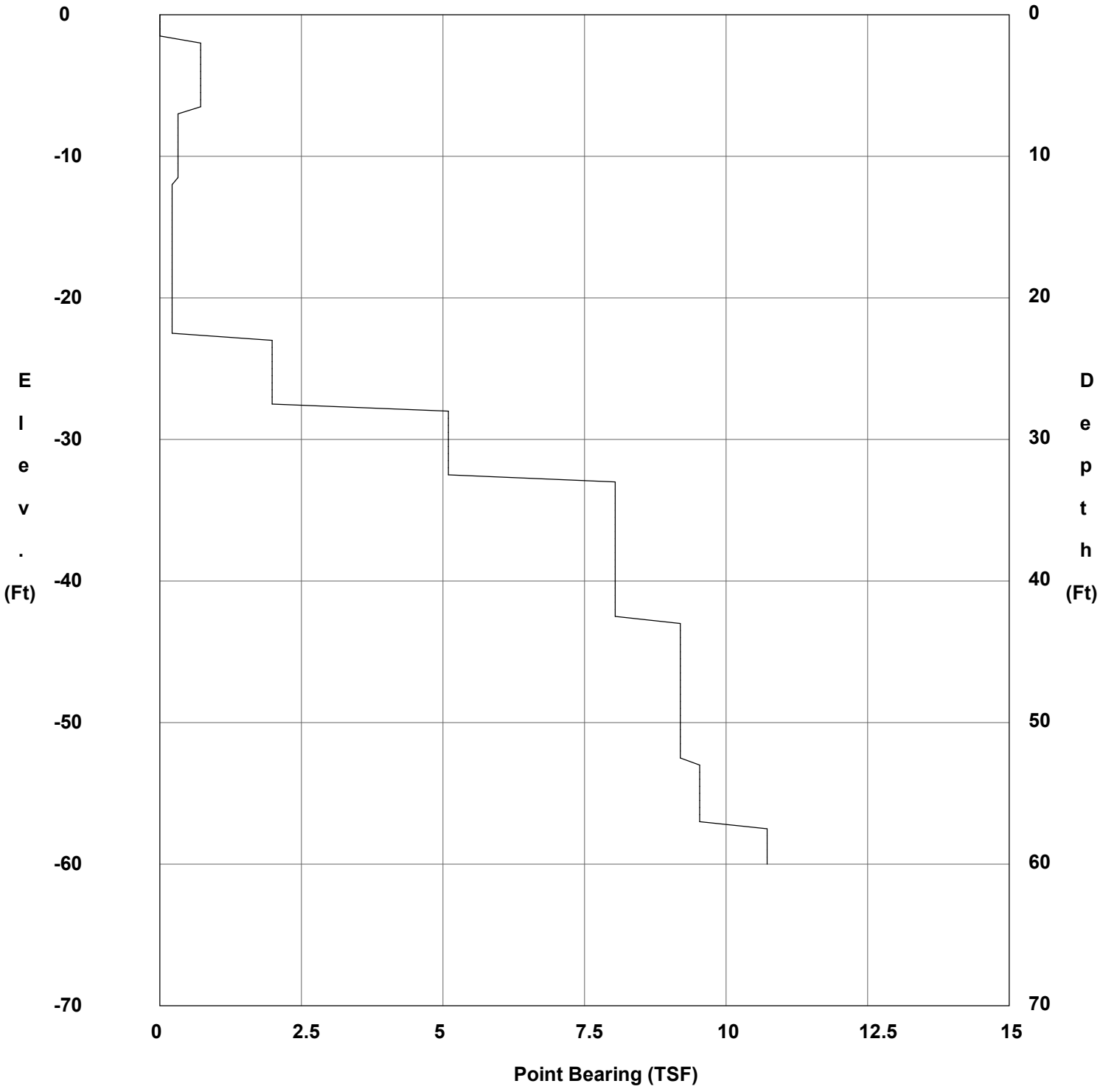
POINT BEARING DESIGN

WinCore
Version 3.3

County		Hole	B-04	District	Somerville
Highway		Structure	Bridge	Date	1/10/2024
Control		Station		Grnd. Elev.	0.00 ft
		Offset		GW Elev.	-18.00 ft

Diameters Below Tip Checked = 2

TCP Bearing Values Used



SKIN FRICTION DESIGN

WinCore
Version 3.3

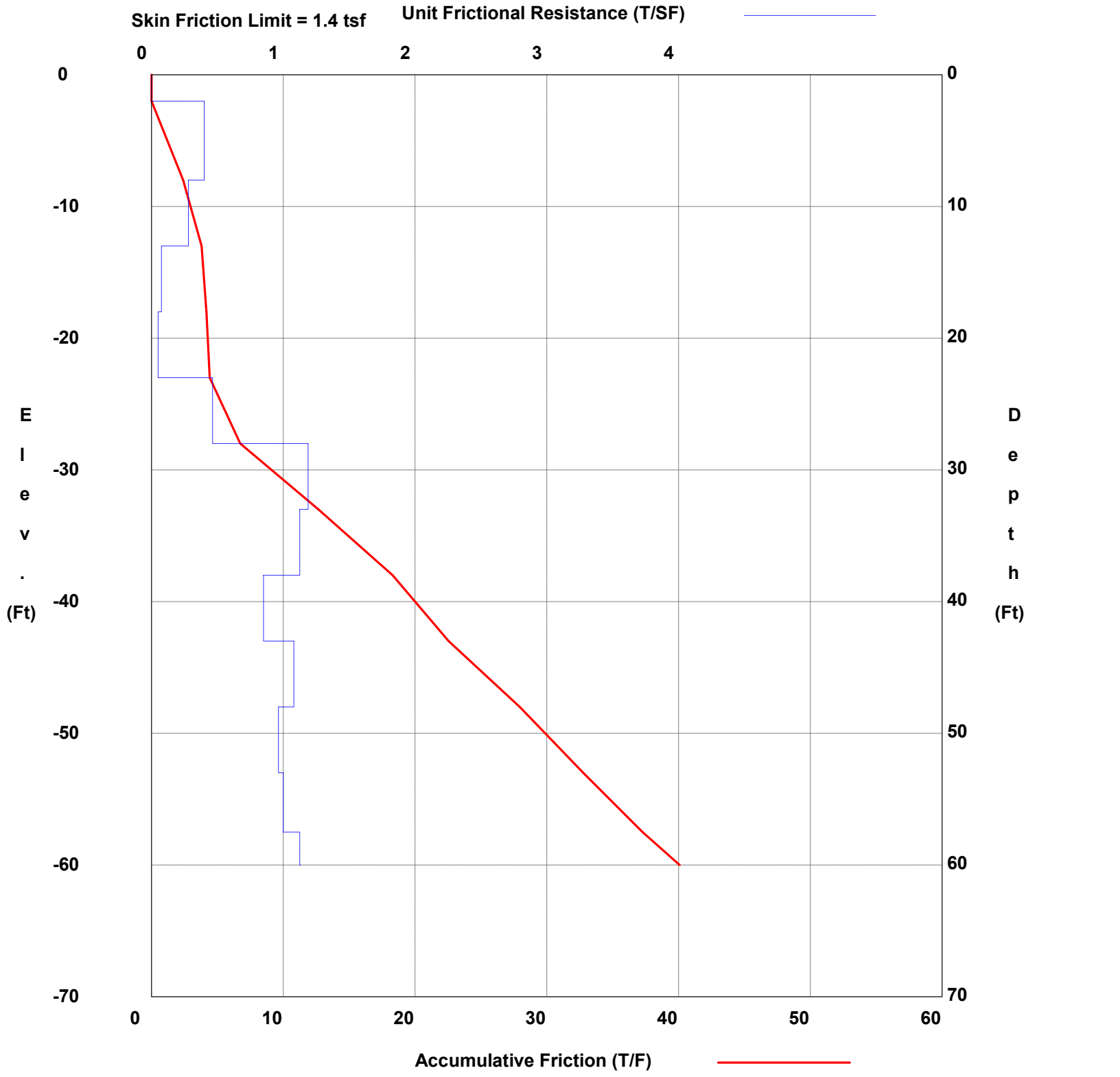
County		Hole	B-04	District	Somerville
Highway		Structure	Bridge	Date	1/10/2024
Control		Station		Grnd. Elev.	0.00 ft
		Offset		GW Elev.	-18.00 ft

Piling Design: No Soil Reduction Factor

Driving refusal maybe encountered below 28-feet

TCP Friction Values Used

Skin Friction Limit = 1.4 tsf



Appendix F - Terms And Symbols used on Boring Logs

UNIFIED SOIL CLASSIFICATION SYSTEM

UNIFIED SOIL CLASSIFICATION AND SYMBOL CHART

COARSE-GRAINED SOILS (more than 50% of material is larger than No. 200 sieve size.)			
GRAVELS More than 50% of coarse fraction larger than No. 4 sieve size	Clean Gravels (Less than 5% fines)	GW	Well-graded gravels, gravel-sand mixtures, little or no fines
		GP	Poorly-graded gravels, gravel-sand mixtures, little or no fines
	Gravels with fines (More than 12% fines)	GM	Silty gravels, gravel-sand-silt mixtures
		GC	Clayey gravels, gravel-sand-clay mixtures
SANDS 50% or more of coarse fraction smaller than No. 4 sieve size	Clean Sands (Less than 5% fines)	SW	Well-graded sands, gravelly sands, little or no fines
		SP	Poorly graded sands, gravelly sands, little or no fines
	Sands with fines (More than 12% fines)	SM	Silty sands, sand-silt mixtures
		SC	Clayey sands, sand-clay mixtures
FINE-GRAINED SOILS (50% or more of material is smaller than No. 200 sieve size.)			
SILTS AND CLAYS Liquid limit less than 50%		ML	Inorganic silts and very fine sands, rock flour, silty of clayey fine sands or clayey silts with slight plasticity
		CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, lean clays
		OL	Organic silts and organic silty clays of low plasticity
SILTS AND CLAYS Liquid limit 50% or greater		MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, elastic silts
		CH	Inorganic clays of high plasticity, fat clays
		OH	Organic clays of medium to high plasticity, organic silts
HIGHLY ORGANIC SOILS		PT	Peat and other highly organic soils

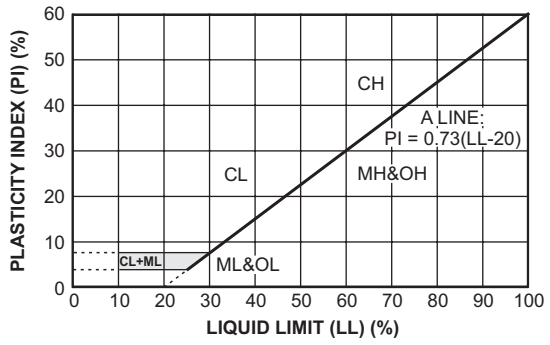
LABORATORY CLASSIFICATION CRITERIA

GW	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{D_{30}}{D_{10} \times D_{60}}$ between 1 and 3	
GP	Not meeting all gradation requirements for GW	
GM	Atterberg limits below "A" line or P.I. less than 4	Above "A" line with P.I. between 4 and 7 are borderline cases requiring use of dual symbols
GC	Atterberg limits above "A" line with P.I. greater than 7	
SW	$C_u = \frac{D_{60}}{D_{10}}$ greater than 4; $C_c = \frac{D_{30}}{D_{10} \times D_{60}}$ between 1 and 3	
SP	Not meeting all gradation requirements for GW	
SM	Atterberg limits below "A" line or P.I. less than 4	Limits plotting in shaded zone with P.I. between 4 and 7 are borderline cases requiring use of dual symbols.
SC	Atterberg limits above "A" line with P.I. greater than 7	

Determine percentages of sand and gravel from grain-size curve. Depending on percentage of fines (fraction smaller than No. 200 sieve size), coarse-grained soils are classified as follows:

Less than 5 percent ..... GW, GP, SW, SP
More than 12 percent ..... GM, GC, SM, SC
5 to 12 percent ..... Borderline cases requiring dual symbols

PLASTICITY CHART



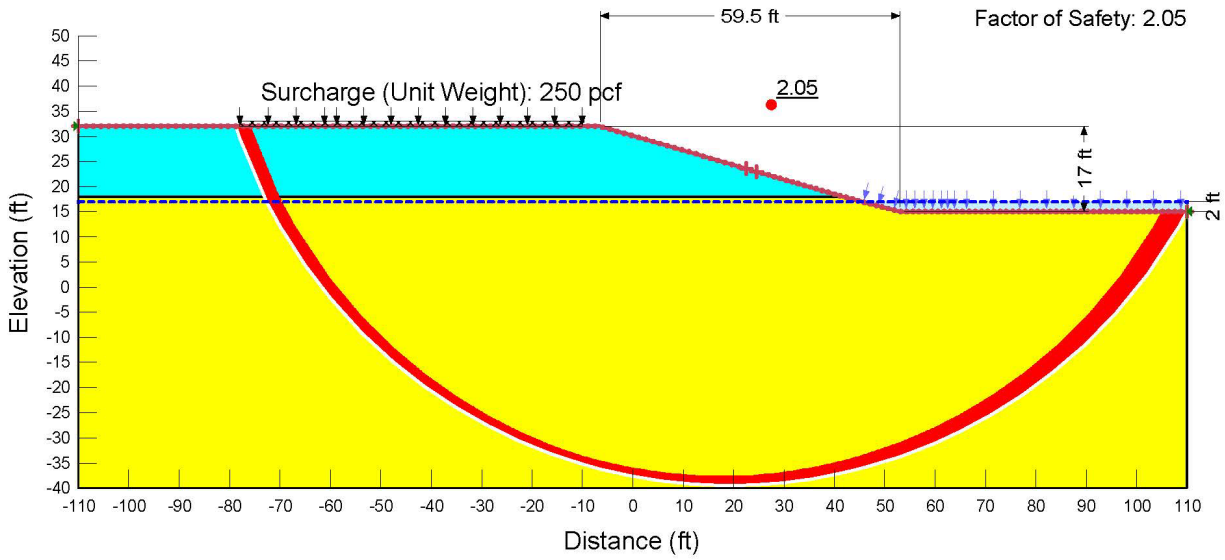
TERMS DESCRIBING SOIL CONSISTENCY

Fine Grained Soils		Coarse Grained Soils		
Description	Penetrometer Reading (tsf)	Penetration Resistance (blows/ft)	Description	Relative Density
Soft	0.0 to 1.0	0 to 4	Very Loose	0 to 20%
Firm	1.0 to 1.5	4 to 10	Loose	20 to 40%
Stiff	1.5 to 3.0	10 to 30	Medium Dense	40 to 70%
Very Stiff	3.0 to 4.5	30 to 50	Dense	70 to 90%
Hard	4.5+	Over 50	Very Dense	90 to 100%

Appendix H - Slope Stability Analysis Results

SHORT TERM SLOPE SABILITY ANALYSIS – NAIL CREEK- 3.5H:1V

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
	Clayey Sand to Sandy Lean Clay	Mohr-Coulomb	125	800	0
	Fat Clay	Mohr-Coulomb	115	800	0



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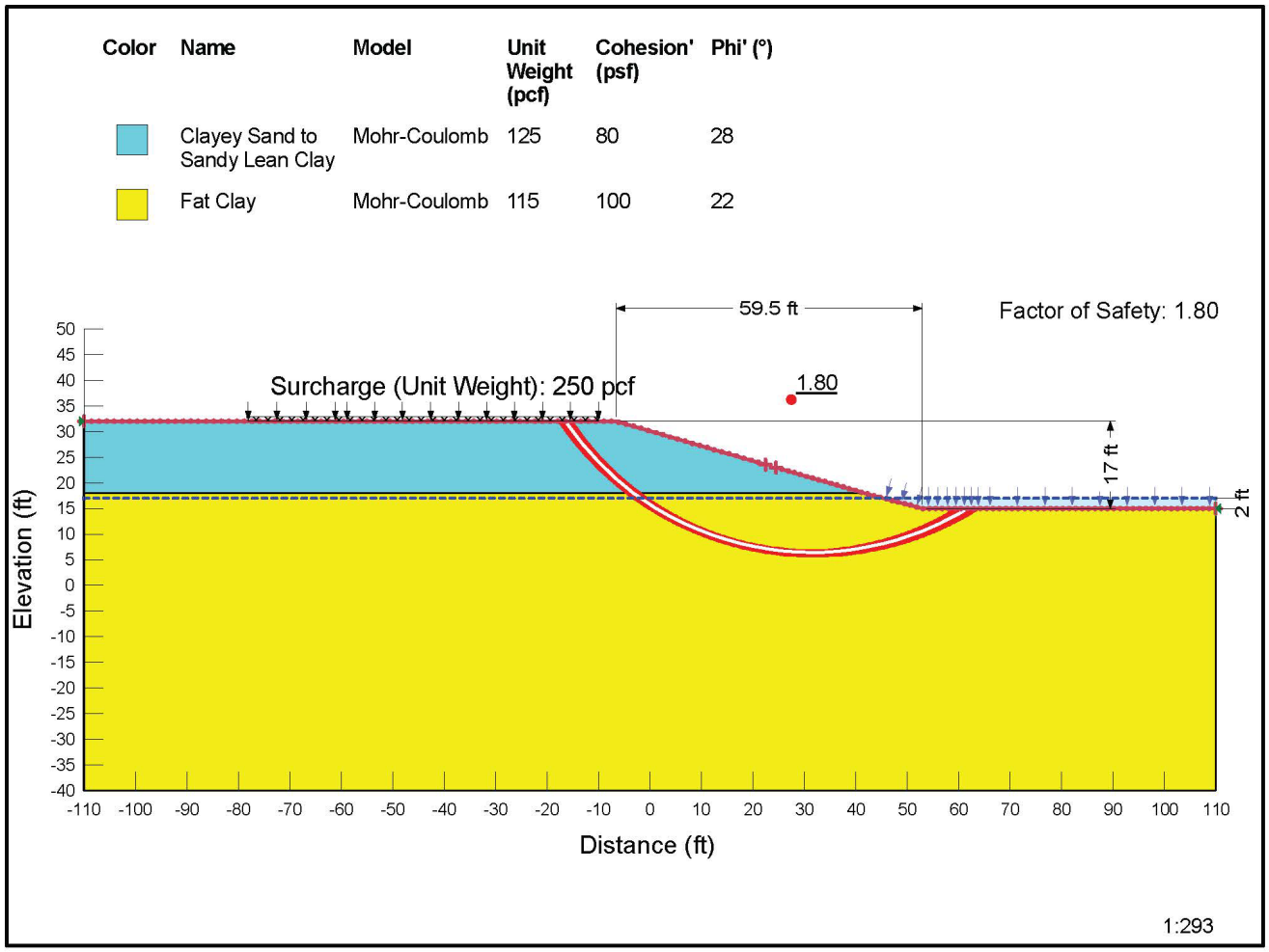
LONG TERM SLOPE SABILITY ANALYSIS – NAIL CREEK- 3.5H:1V

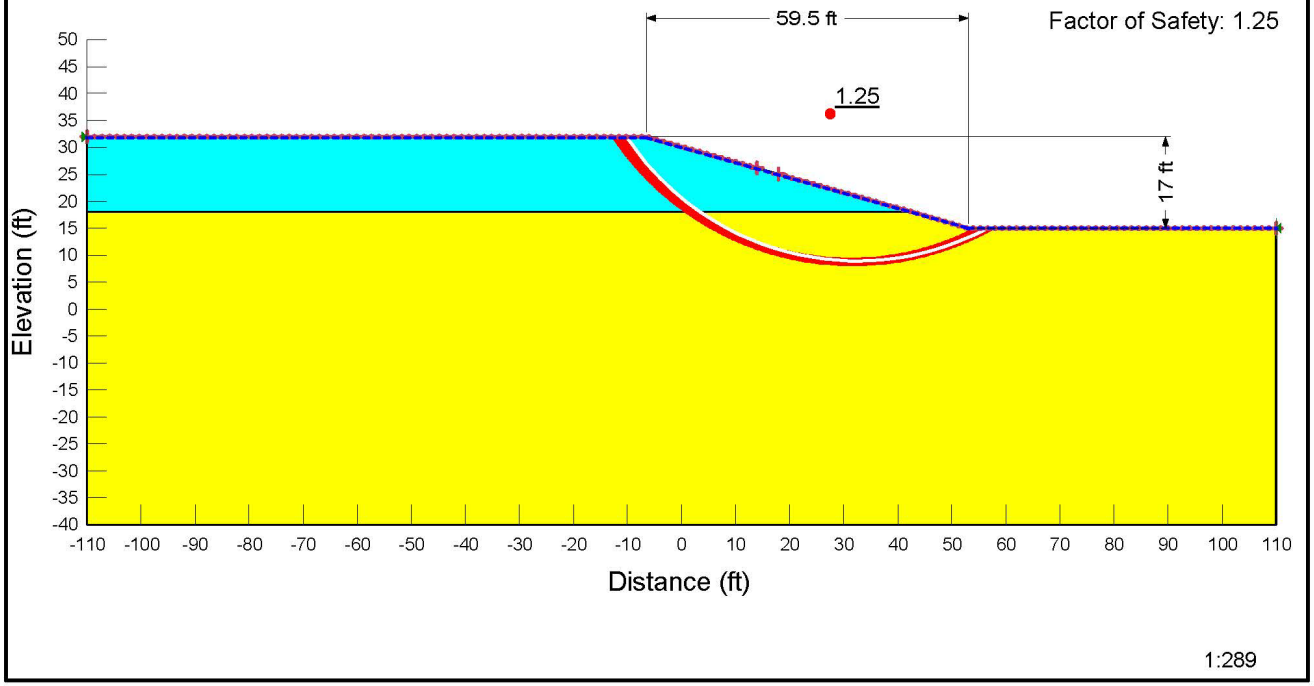


Project No. 23-0722

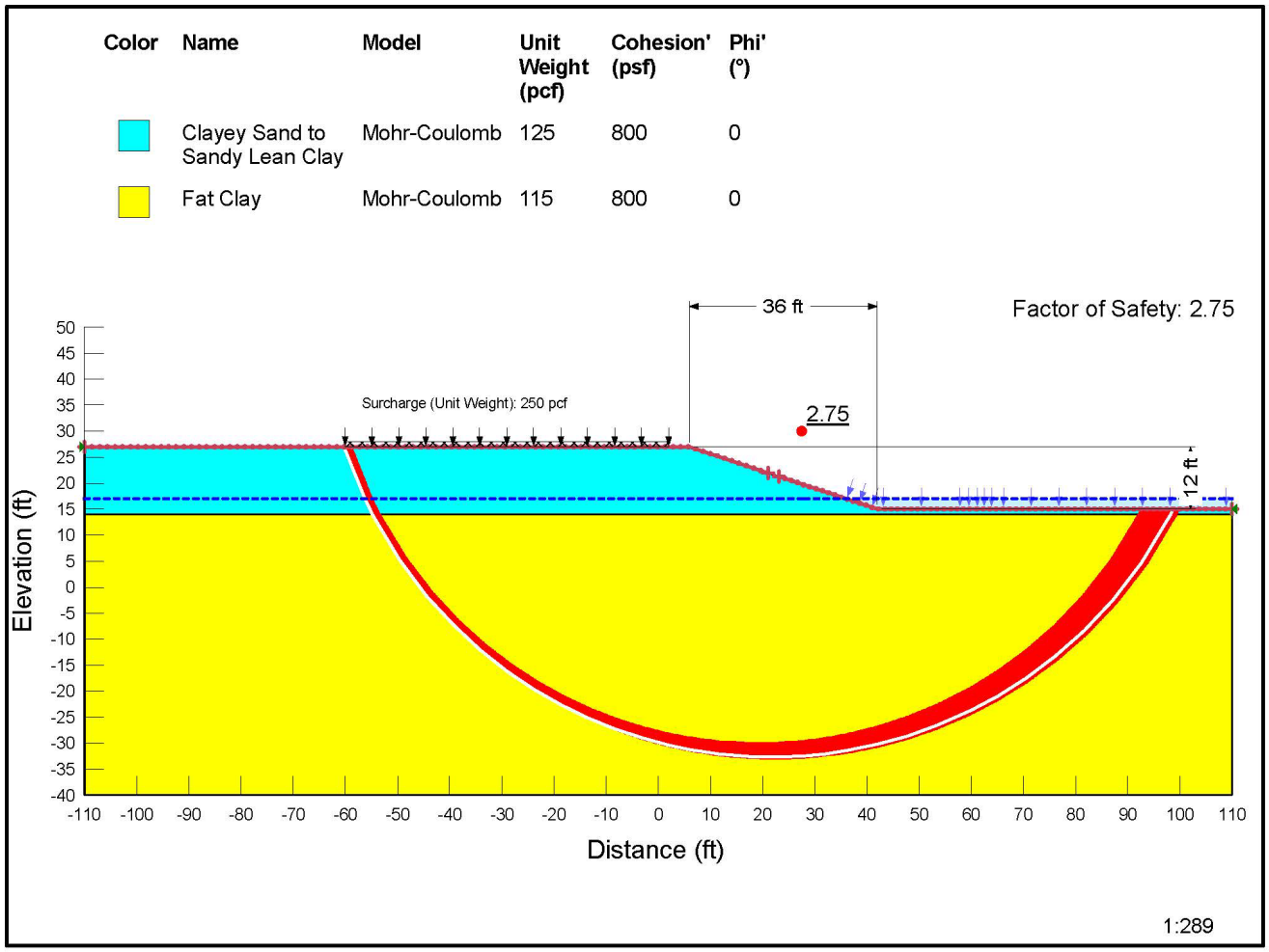
Lake Somerville Trail Bridge Replacement

RAPID DRAWDOWN SLOPE SABILITY ANALYSIS – NAIL CREEK- 3.5H:1V

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
	Clayey Sand to Sandy Lean Clay	Mohr-Coulomb	125	90	28
	Fat Clay	Mohr-Coulomb	115	100	22

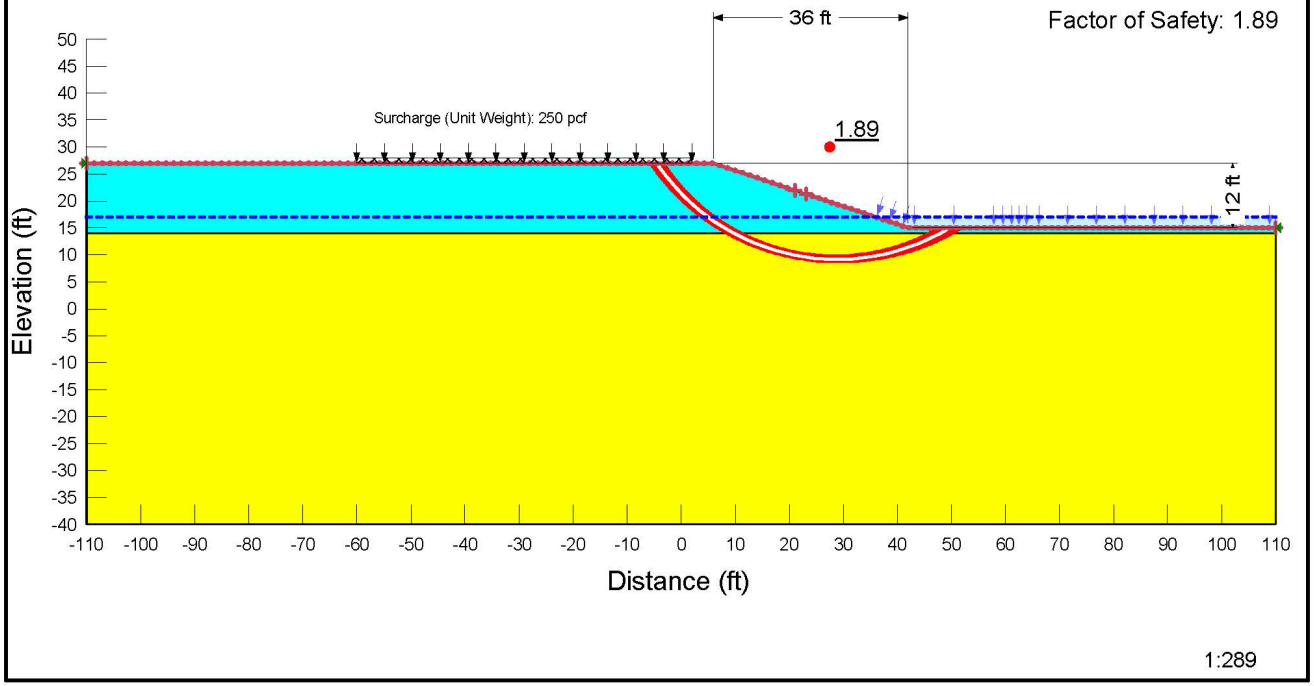


SHORT TERM SLOPE SABILITY ANALYSIS – NAIL CREEK- 3H:1V



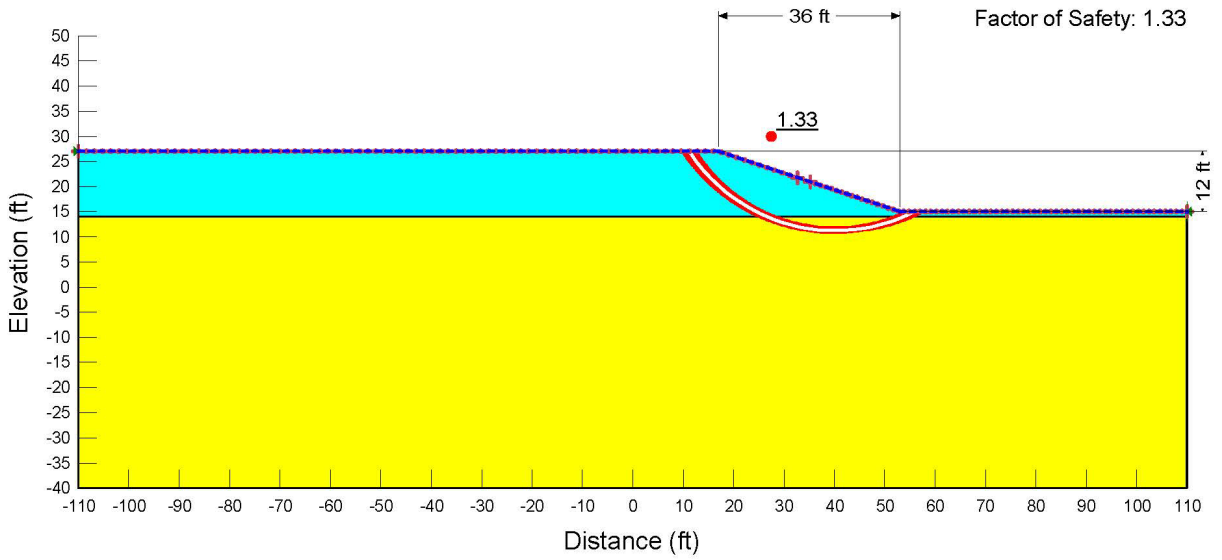
LONG TERM SLOPE SABILITY ANALYSIS – NAIL CREEK- 3H:1V

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
	Clayey Sand to Sandy Lean Clay	Mohr-Coulomb	125	90	28
	Fat Clay	Mohr-Coulomb	115	100	22



RAPID DRAWDOWN SLOPE SABILITY ANALYSIS – NAIL CREEK- 3H:1V

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)
	Clayey Sand to Sandy Lean Clay	Mohr-Coulomb	125	90	28
	Fat Clay	Mohr-Coulomb	115	100	22



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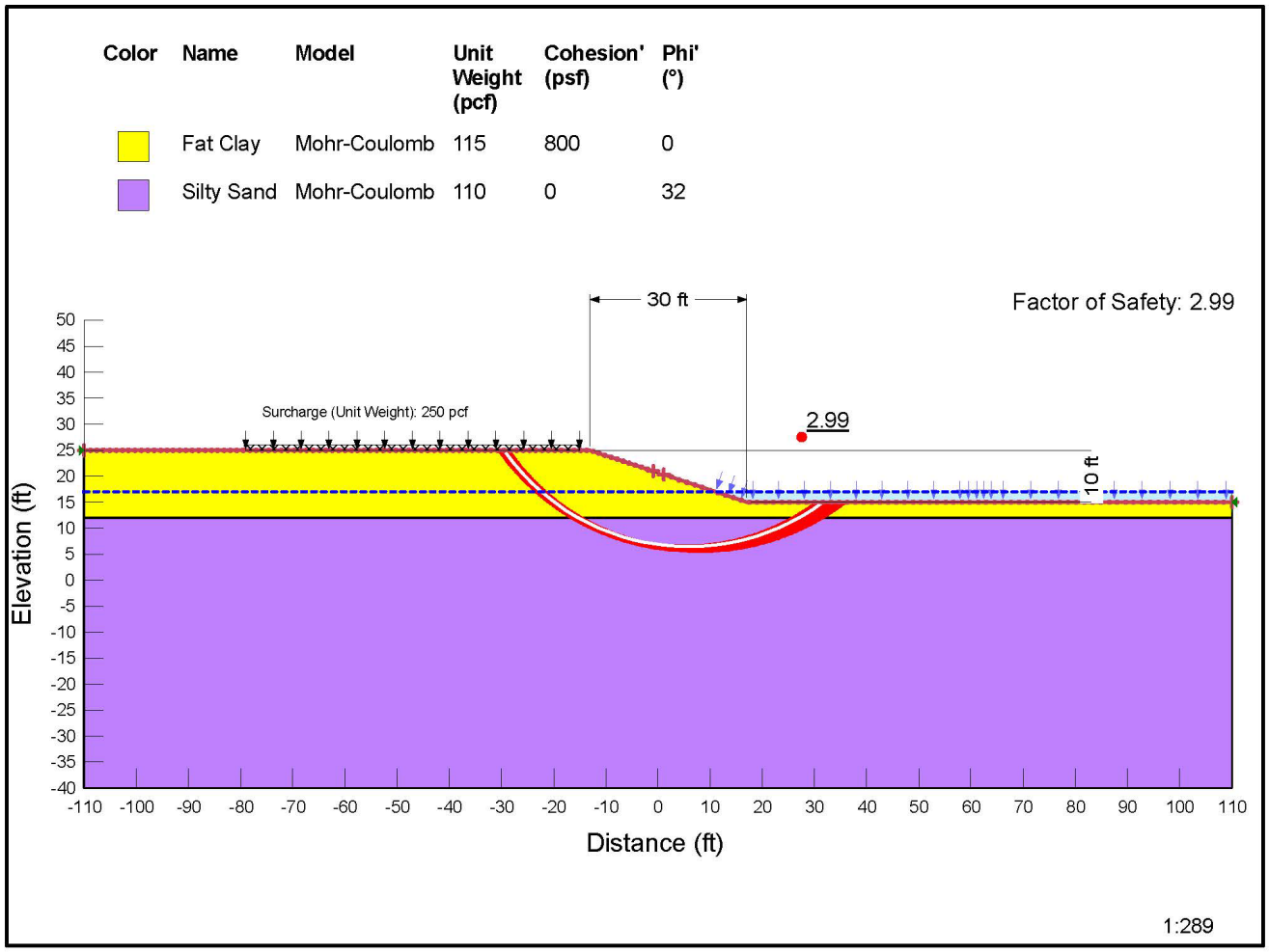
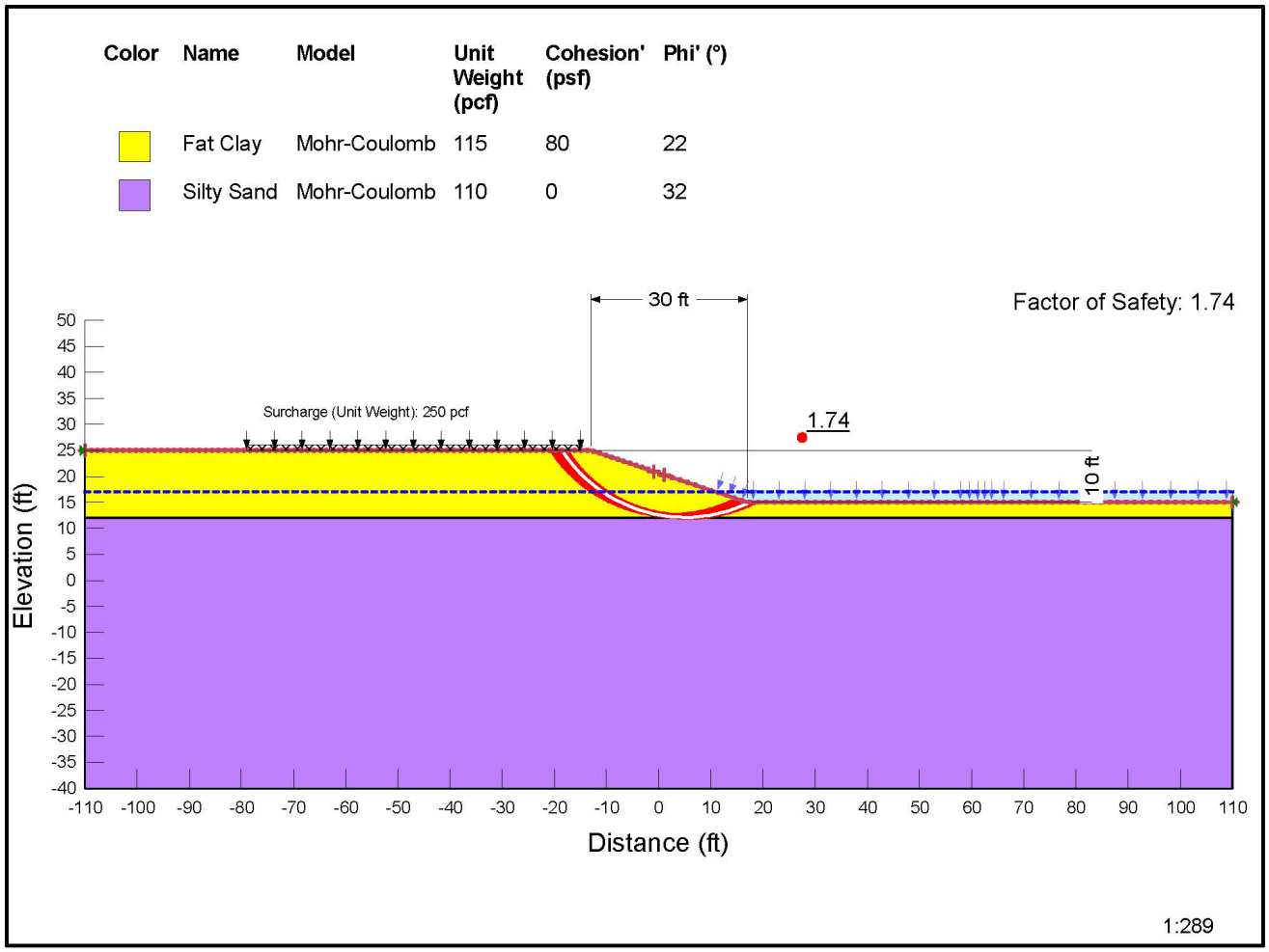
SHORT TERM SLOPE SABILITY ANALYSIS – YEGUA CREEK- 3H:1V



Project No. 23-0722

Lake Somerville Trail Bridge Replacement

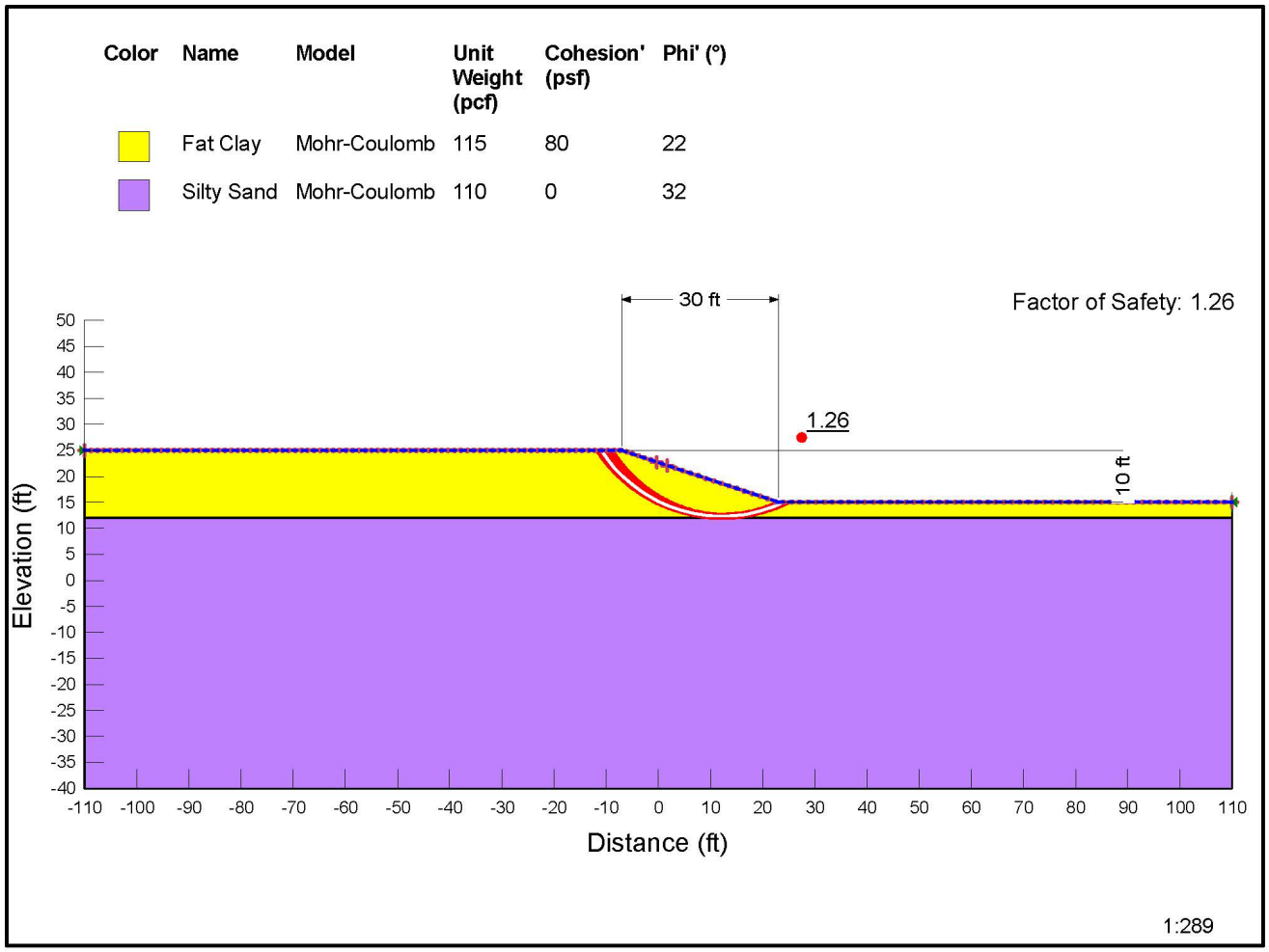
LONG TERM SLOPE SABILITY ANALYSIS – YEGUA CREEK- 3H:1V



Project No. 23-0722

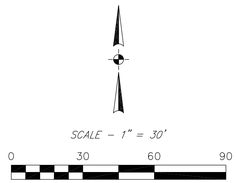
Lake Somerville Trail Bridge Replacement

RAPID DRAWDOWN SLOPE SABILITY ANALYSIS – YEGUA CREEK- 3H:1V



Project No. 23-0722

Lake Somerville Trail Bridge Replacement



LEGEND

- BENCHMARK
- SIGN
- AREA OF CONCRETE
- AREA OF GRAVEL
- TREE NO. & LOCATION
- CRITICAL ROOT ZONE

NOTES:

The survey shown hereon has been prepared as the result of an on the ground survey completed on June 22, 2023.

The bearings shown hereon are referenced to the Texas Coordinate System of 1983, Central Zone.

The Surveyor has not abstracted the subject property, nor made any independent investigation or search for easements of record, restrictive covenants or any other encumbrances.

This is NOT a boundary survey. Any lines or other information representing the perimeter of the property are from public records or other sources and are not intended to be boundaries as defined by the Texas Board of Professional Land Surveying Professional & Technical Standards.

This survey was prepared without the benefit of a title commitment or report. The surveyor has not abstracted the subject property, nor made any independent investigation or search for easements of record, restrictive covenants or any other encumbrances.

By scaling the surveyed tract onto the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Map (FIRM) No. 48287C0325C, revised date April 16, 2014, a portion of the subject area is in ZONE A, defined as special flood hazard areas subject to flooding by the 1% annual chance flood without base flood elevations determined, and a portion of the subject area is in ZONE X (unshaded), defined as areas determined to be outside the 0.2% annual chance floodplain. The Surveyor makes no representation as to the accuracy of said FIRM or that it is the most current published flood map.

The improvements shown hereon represent the outline at ground level. The Surveyor has not located any underground buildings, overhead protrusions or improvements not obvious and located at ground level, unless otherwise noted.

Surveyor has not identified any geological or environmental conditions in connection with the subject property and Surveyor fully disclaims any and all responsibility related to issues or claims related thereto or resulting there from.

The elevations (and/or contours) shown hereon are referenced to T.B.M. "B" (5/8" iron rod capped "JONES|CARTER", N: 10087639.71 E: 3446622.22, Elev: 244.76', NAVD88, GEOID18) and were determined as a result of an OPUS computed coordinate from a static GPS observation completed on June 19, 2023.

TREE LIST

TAG. NO.	DESCRIPTION
2017	11" Twin Chinese Elm (6",8")
2018	12" Chinese Elm
2019	13" Twin Chinese Elm (6",10")
2020	7" Chinese Elm
2021	18" Twin Chinese Elm (12",12")
2022	6" Chinese Elm
2023	9" Chinese Elm
2024	9" Chinese Elm
2062	14" Multi-stem Chinese Elm (8",7",6")
2063	9" Multi-stem Chinese Elm (5",5",4")
2064	10" Twin Chinese Elm (6",4")
2065	13" Twin Chinese Elm (9",8")
2066	5" Chinese Elm
2067	9" Twin Chinese Elm (6",6")
2068	9" Twin Chinese Elm (7",5")
2069	9" Ash
2070	4" Ash
2071	8" Ash
2192	6" Pecan
2193	12" Multi-stem Cedar Elm (8",4",4")
2202	9" Cedar Elm
2203	5" Cedar Elm
2204	6" Cedar Elm
2205	6" Cedar Elm
2206	9" Live Oak

SURVEYOR'S CERTIFICATION

To: The Lake Somerville State Park Nails Creek Unit:

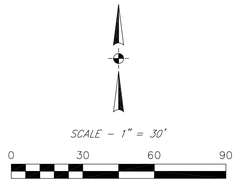
This survey substantially complies with the current Texas Society of Professional Surveyors Standards and Specifications for a Category VI Condition II Survey.

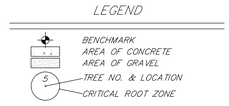
Drawing Date: July 14, 2023.
Revised Date: September 13, 2023.

Rex L. Hackett
Registered Professional Land Surveyor No. 5573
3100 Alvin Devane Blvd. Ste 150, Austin, TX 78741
512-441-9493

TOPOGRAPHIC SURVEY
OF A PORTION OF
NAILS CREEK
IN THE
H. BEST SURVEY, A-2
LEE COUNTY, TEXAS
JULY 2023

QUIDDITY
Texas Board of Professional Engineers and Land Surveyors Reg. No. 10046100
3100 Alvin Devane Boulevard, Suite 150 • Austin, TX 78741 • 512.441.9493





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The elevations (and/or contours) shown hereon are referenced to T.B.M. "A" (5/8" iron rod capped "JONES|CARTER", N: 10098159.36, E: 3438811.15, Elev: 246.55', NAVD88, GEOID18) and were determined as a result of an OPUS computed coordinate from a static GPS observation completed on June 14, 2023.

TREE LIST

TAG. NO.	DESCRIPTION
1020	11" Twin Chinese Elm (8",5")
1021	7" Twin Pecan (6",3")
1035	9" Cedar Elm
1036	33" Live Oak
1037	14" Ash
1038	26" Live Oak Dead
1091	18" Cedar Elm Dead
1092	8" Cedar Elm
1093	7" Cedar Elm
1094	9" Twin Cedar Elm (7",4")
1095	9" Cedar Elm
1096	6" Cedar Elm
1097	9" Cedar Elm
1098	8" Cedar Elm
1099	9" Cedar Elm
1100	5" Cedar Elm
1101	12" Cedar Elm
1102	9" Cedar Elm
1103	7" Cedar Elm
1104	14" Twin Chinese Elm (12",7")
1105	9" Ash
1106	16" Ash
1207	12" Cedar Elm
1208	6" Cedar Elm
1209	8" Cedar Elm
1210	6" Cedar Elm
1212	8" Cedar Elm
1213	10" Cedar Elm
1214	5" Cedar Elm
1215	6" Cedar Elm
1216	7" Cedar Elm
1217	5" Cedar Elm
1218	21" Ash
1219	9" Cedar Elm
1220	15" Ash
1221	7" Cedar Elm
1222	10" Cedar Elm
1223	4" Cedar Elm
1224	8" Cedar Elm
1225	8" Cedar Elm
1226	10" Chinese Elm
1227	7" Twin Chinese Elm (5",4")
1241	12" Pecan
1244	29" Cedar Elm
1245	20" Cedar Elm

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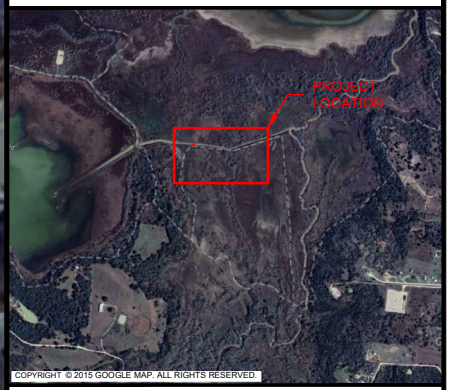
TOPOGRAPHIC SURVEY
OF A PORTION OF
YEGUA CREEK
IN THE
R.J.W. REEL SURVEY, A-17
LEE AND BURLESON COUNTIES, TEXAS
JULY 2023

QUIDDITY
Texas Board of Professional Engineers and Land Surveyors Reg. No. 10046100
3100 Alvin Devane Boulevard, Suite 150 • Austin, TX 78741 • 512.441.9493

VICINITY MAP



SOIL BORING COORDINATES

BORING	DEPTH	LATITUDE	LONGITUDE
B-2	6'	30°17'51.50"N	96°41'10.40"W

LEGEND

SYMBOL	DESCRIPTION
⊕	BORING LOCATIONS

TOLUNAY-WONG ENGINEERS

TWE Boring Location Plan
LAN Lake Somerville
Somerville, TX

Drawn	B.S.H	7/3/25
Checked	J.B	
Approved	D.R.R.	
Scale	N.T.S.	

TWE DRAWING NO. 25.53.068-2

LOG OF BORING B-2

PROJECT: Lake Somerville Trail Bridge Replacement
Sommerville, TX

CLIENT: Lockwood, Andrews & Newnam, Inc.
Corpus Christi, Tx

COORDINATES: N 30° 17' 51.50"
W 96° 41' 10.40"

SURFACE ELEVATION:

DRILLING METHOD:
Dry Augered: 0' to 6'
Wash Bored: to

ELEVATION (FT) / DEPTH (FT)	SAMPLE TYPE	SYMBOL	MATERIAL DESCRIPTION	(P) POCKET PEN (tsf) (T) TORVANE (tsf)	STD. PENETRATION TEST BLOWCOUNT	MOISTURE CONTENT (%)	DRY UNIT WEIGHT (pcf)	LIQUID LIMIT (%)	PLASTICITY INDEX (%)	COMPRESSIVE STRENGTH (tsf)	FAILURE STRAIN (%)	CONFINING PRESSURE (psi)	PASSING #200 SIEVE (%)	OTHER TESTS PERFORMED
0			Medium dense brown CLAYEY SAND (SC)	(P)2.0		10		30	13				38	
			Soft brown SANDY LEAN CLAY (CL)		2/6" 2/6" 2/6"	19		31	15				50	
5			Loose brown and dark gray LEAN CLAY with SAND (CL)		2/6" 4/6" 4/6"	22		41	23				75	
			Bottom @ 6'											
10														
15														
20														
25														
30														
35														

COMPLETION DEPTH: 6 ft
DATE BORING STARTED: 6/30/25
DATE BORING COMPLETED: 6/30/25
LOGGER: B.Harris
PROJECT NO.: 25.53.068

NOTES: Groundwater not encountered during drilling. Boring was terminated at 6-ft.